

APPENDIX TO VOL. XXVIII.

MEMOIRS.

Mr. JOHN GEORGE BODMER was born at Zurich, in Switzerland, on the 6th of December, 1786. When only a few years old, and scarcely able to handle a knife, he evinced his constructive talents by converting turnips, carrots, and pins into wheels, carts, and other mechanical playthings. As he grew older, these unpromising and perishable materials were soon laid aside and exchanged for wood and iron; in the combination of which, to produce desired effects, he showed great ingenuity.

Young Bodmer, although he was never idle, could not for a long time be brought to see the necessity of going to school; which, considering that the masters in those days took care that instruction and corporal chastisement should have about an equal share of their attention, was not perhaps to be wondered at. However, as soon as his mind, through the earnest representations of his mother, became open to conviction upon this point, he applied himself to the study of those subjects which were then taught at schools (the dead languages excepted) with the greatest diligence and success.

His parents had intended him for a merchant's office, but he evinced such a decided aversion to that pursuit, that they finally determined to let him follow the bent of his mind; and after leaving school, he was accordingly, when about thirteen or fourteen years old, apprenticed to a clever millwright of the name of Mesmer, who carried on business in the Canton of Thurgovia, at some distance from Zurich. Bodmer, finding himself now engaged in occupations congenial to his mind, very soon excelled not only his fellow-apprentices, but also his experienced fellow-workmen, in the execution of the work confided to him, and was, after a short time, relieved from the drudgery which generally falls to the share of the apprentice. His master consulted and employed him in all cases where superior workmanship and knowledge, or especial care and foresight, were required. Mr. Bodmer, in after years, frequently and with great glee told how, on one occasion, he had to help, as confidential assistant, in the construction of a machine which was intended to be endowed with perpetual motion; when, after every unsuccessful trial, his master would observe, that only a trifling alteration was now required to cause

the lever or wheel to pass over the dead point. The apprentice was all the time well aware, and unhesitatingly gave it as his opinion, that the machine would never answer. It is not a little curious that, when yet quite a boy, and before he went to school, Mr. Bodmer, self-taught, practised mechanical drawing; to the great amusement of his companions, who had not the least idea of the meaning of it.

Soon after having served his apprenticeship, Mr. Bodmer erected a small workshop at the village of Küssnacht, on the borders of the lake of Zurich, principally for the execution and repair of mill-wright work. On one occasion, one of the workmen took great care to carry, and display in as conspicuous a manner as possible, a turned iron spindle; the turning of iron being a feat at that time but rarely performed.

As the French Revolution broke out not many years after Mr. Bodmer's birth, and was soon followed by the wars of the French Republic, and subsequently by those of the Empire, it is not surprising that the military character and incidents of the age should have strongly biassed Mr. Bodmer's mind; and it cannot be wondered at that his inventive faculties were directed to improvements in the construction of guns and projectiles, to which he devoted himself in after-life, whenever other occupations left him at liberty to do so. The first task which Mr. Bodmer set himself to accomplish in this direction was to devise a shell which, being fired from a rifled cannon, should explode on striking the object aimed at, instead of requiring a fusee, as usual. This he effected by screwing into the aperture or neck of the shell, where, under ordinary circumstances, the fusee is inserted, a perforated bush of brass, on the top of which, after charging the shell, a capsule of a fulminating compound was placed. Finally, the upper end of this bush was covered by a cap in such a manner that, on the shell striking the object aimed at, the cap was crushed, and coming into violent contact with the explosive compound, the latter was ignited and set fire to the charge. The first shell constructed upon this principle, by way of experiment, was finished on the 1st of January, 1806, and was caused to explode by being dropped from a rock in the immediate neighbourhood of Küssnacht.

Shortly afterwards Mr. Bodmer was introduced to and went into partnership with Baron d'Eichthal, who had purchased the conventual buildings of St. Blaise, in the Black Forest, with the intention of appropriating them to the purposes of a cotton-mill. Workshops were accordingly established, the requisite alterations in the building made, and the water-wheels, shafting, and gearing, as well as the whole of the machinery, constructed and erected according to Mr. Bodmer's own plans, and under his immediate superintendence and direction. The mental and bodily labour at this

juncture was so much the more arduous, as the spot selected was situated in a narrow valley, surrounded by hills of considerable height, and all the materials required for the undertaking, the timber excepted, had to be conveyed from places at a distance over hilly roads; so that Mr. Bodmer's personal attendance, directions, and instructions, in many places were indispensable.

It was about this time that Mr. Bodmer first conceived the idea of what became subsequently known in Germany by the comprehensive name of "Bandvereinigungs System" (Band-uniting system). This consists in placing any suitable, or desirable, number of carding-engines in a row side by side, with their doffers to the front, and causing the same to discharge their slivers simultaneously, through delivery-rollers moving at the same superficial velocity, upon a belt which, travelling along the front of the carding-engines in question, with a linear velocity corresponding with that of the discharge of the slivers, conveyed the latter, laid side by side, in a broad band towards a machine called a lap-machine; where the slivers were wound in successive spiral layers upon a wooden roller, to which, by means of a drum, the same circumferential speed as that of the belt was imparted. As soon as a sufficient quantity of slivers had been wound upon this roller, or lap, it could be, with the greatest facility and despatch, replaced by another wooden roller without stoppage, and the work went on as before. A suitable number of these laps were placed behind the finishing carding-engines, or drawing-frames, as the case might be, upon two or three or any convenient number of unwinding drums, the circumferential velocity of which corresponded with that of the feed or drawing rollers; so that 'doubling' could be carried out to any extent, whilst it was impossible for the slivers to become stretched, or otherwise injured, as they often happened to be on being forcibly withdrawn from the mass compressed into the cans, which then were (and perhaps even now are, at least in England) in general use. The same principle was to be carried out with regard to the slubbing and roving frames, and even to the feeding portion of the spinning machinery. When Mr. Bodmer proposed to his partner that the machinery for their mill should be constructed upon this plan, Baron d'Eichthal expressed himself as being reluctant to permit these innovations, because, as he said, if such a system were at all practicable, or superior to that in common use, it must have been long ago adopted in England. This was so far from being the case that, although Mr. Bodmer's improvements found great favour both in France and in Germany, there was scarcely a trace of them in the cotton-mills of England, forty years after the above recorded objections had been made by Baron d'Eichthal.

The progress of the Napoleonic wars having suggested the

expediency of establishing a manufactory of fire-arms at St. Blaise, a few skilled workmen were sent for from St. Etienne, in France, to form the nucleus of this new branch of manufacture. Instead, however, of confining himself to the ordinary process of gun-making by manual labour, Mr. Bodmer invented and successfully applied a series of special machines by which the various parts—more especially those of the lock—were shaped and prepared for immediate use, so as to insure perfect uniformity and to economise labour. Amongst these machines there was also a planing-machine on a small scale; and Mr. Bodmer has been heard to observe how strange it was that it should not have occurred to him to produce a larger machine of the same kind, with a view to its use for general purposes. A beautifully-finished rifle, having Mr. Bodmer's name and the place of manufacture engraved upon the lock-plate, is now extant; also an equally well-executed breech-loading rifle, with bayonet, intended for the use of infantry, and made according to Mr. Bodmer's plan, about the same time, say between the years 1809 and 1813. As the percussion-lock was not known, Mr. Bodmer had, of course, to contend with great difficulties; and it is scarcely necessary to observe that the principle was never adopted, the time for a change of such magnitude having evidently not yet arrived.

As the operatives for the cotton-mill had to be obtained from the surrounding villages, some of which were situated at a distance of many miles from St. Blaise, and as there were but few houses in the immediate neighbourhood of the former convent, whilst the accommodation in the conventual buildings was most ample, the whole of the workpeople were both fed and lodged in the latter. And in order to save labour in preparing the tables for the meals and in serving up the food, and to render the work of feeding such a large number of people more expeditious and systematic, Mr. Bodmer had a railway constructed, with branches or sidings to every table, upon which the plates, dishes, &c., &c., were conveyed on small trucks, from the kitchen and back again.

The Grand Duke of Baden, appreciating his inventive genius, and his mechanical and administrative talents, and being anxious to secure his services for the benefit of the country, appointed him Director General of the Iron Works, which were Government property. As Mr. Bodmer still retained the management of the establishment at St. Blaise, his time was so much occupied that he generally spent a part of the night in travelling backward and forward, so as to be able to devote the day to his usual duties. He was frequently so intent upon his studies, or upon the accomplishment of any task which he happened to have set to himself, that he would forget to take either food or rest for thirty-six hours together. The climate of the Black Forest is most severe in

winter, the country being covered to the depth of many feet with snow; and Mr. Bodmer had frequently to perform his journeys over the mountains seated in, or astride on, a small open sledge, which, owing to the unevenness of the path, was very apt to become upset.

A further appointment, which was almost forced upon Mr. Bodmer by the Grand Duke, was that of Inspector of the Matériel of Artillery, with the rank of Captain, at a salary of 4,000 florins, or about £400 sterling, a year. In this capacity he had to contend against the apathy, if not hostility, of the General of Artillery, who could not understand either the necessity or the expediency of altering or improving anything to the sight or use of which he had been all his life accustomed. A number of coloured drawings, chiefly made by young artillerists under Captain Bodmer's tuition and direction, are still extant, showing a variety of modifications of and improvements in ammunition-waggons, gun and mortar carriages, &c., designed by him, and carried out to his orders. On one occasion a hammerman pronounced a certain forging intended to form a part of an ammunition-waggon to be impossible of execution, whereupon Mr. Bodmer had to convince him of the contrary, by finishing the work with his own hands.

The time had now arrived for Mr. Bodmer to carry out his improved rifled breech-loading cannon and self-exploding projectile. A cannon, representing on a reduced scale a 12-pounder, and capable of throwing balls of 1 lb. weight, was accordingly constructed, together with the requisite ammunition; and in the year 1812 Mr. Bodmer took this model cannon with him to Paris, with the intention of exhibiting it before the Emperor Napoleon, and if possible inducing him to introduce the invention in the French army and navy. Napoleon happened to be absent from his capital at the time, but Mr. Bodmer being provided with letters of introduction to one of the principal bankers of Paris, as well as to other gentlemen of high standing, an interview between himself and General Laribosière and other French artillery officers was arranged, during which Mr. Bodmer explained the principle and anticipated effects of his new cannon and projectile. For the purpose of affording Mr. Bodmer the opportunity of practically proving the correctness of his statements, one of his friends placed a large garden, situated at some distance from Paris, at his disposal. General Laribosière, with other officers, and several scientific gentlemen, were invited; and in their presence a small wooden structure filled with straw was ignited by the shell, which had purposely not been filled with powder to the bursting point. The military spectators were not prepared to deny the efficiency of the cannon and its projectile, but they contended that the model was too small to admit of reliable conclusions being drawn, as to

what might be expected from a real 12-pounder. Nevertheless it was intimated to Mr. Bodmer that, if he would join the French artillery, his improvements would doubtless be carried out and adopted. This flattering offer was, however, for many reasons declined; and Mr. Bodmer was soon afterwards obliged to return to his post, without having had the opportunity of seeing the Emperor Napoleon. The circumstances attending the experiments with the model cannon were subsequently recorded in the "*Bulletin de la Société pour l'Encouragement des Arts et Métiers.*"

On returning home, Mr. Bodmer determined to construct a real 12-pounder breech-loading cannon. The work was immediately taken in hand; and when all was ready, about the year 1814, the cannon, with its projectiles, was subjected to a series of experiments, during the space of twelve days, on a large common near the town of Carlsruhe. Unfortunately, the General of Artillery under whose direction the proceedings were carried on, insisted upon first of all, and for many days together, firing solid shot; and when at last the time of the shells came, some accident occurred to the apparatus for closing the breech, so that the experiments had to be abruptly brought to a close. It was, however, found that those shells which were tested exploded much as it was expected they would. But it was likewise observed, that when strong charges of powder were used, whether for the solid or the hollow shot, the circle or zone of lead which embraced the projectile (the lead being poured into a dovetailed recess in the body of the ball, so as to cause it to take into and be guided by the rifle grooves) expanded, in consequence of the increased velocity of rotation, and caused the projectile to deviate from its course, finally becoming completely detached. A document recording, after the requisite explanatory remarks, in a tabular form, the particulars which are considered of importance on such occasions, and signed by the officers present at the time, is still in the hands of Mr. Bodmer's relations. This same cannon, after having been repaired, was a few years later sent to England, and on his first visit to that country, in 1816, Mr. Bodmer made various, but ineffectual, attempts to obtain permission from the Board of Ordnance to have the efficiency of the invention tested. There being thus no prospect of success, the cannon was deposited in a warehouse in London, which together with its contents was at a subsequent period destroyed by fire.

In connection with this matter it may be mentioned, as an interesting fact, that at Mr. Bodmer's request, his brother, Mr. J. J. Bodmer, with the model cannon in his possession, undertook a journey to St. Petersburg, with instructions to offer the invention to the Emperor Alexander. Mr. J. J. Bodmer was very favourably received, and requested to inform his brother that on coming

to St. Petersburg the improved system of artillery should be immediately adopted, and all the means necessary for practically carrying out the invention placed at his disposal. The letters conveying these tidings were however either lost or intercepted, and Mr. J. J. Bodmer, receiving no answer, proceeded to England, by way of Sweden, where, some time afterwards, the two brothers met.

Besides attending to the duties which devolved upon him, in consequence of his Government appointments and his connection with the works of St. Blaise, Mr. Bodmer designed, for one of his brothers who was in business at Zurich, a flour-mill, which differed in some essential particulars from the mills then generally in use. Instead of each set of stones being driven by a small waterwheel, the whole of the machinery connected with the mill was set in motion by a waterwheel of unusual size, which as it derived its power from a river (Limmatt), whose water-level was very fluctuating, was fitted with an apparatus for adjusting the dip of the floats; this consisted of two radial arms, in which the bearings of the shaft were placed, and which could be raised and lowered at pleasure by a simple mechanism. The various sets of millstones were symmetrically arranged in groups of four, and driven from a central spurwheel. Each set could be started and stopped separately, and was besides furnished with a contrivance for accurately adjusting the distance between the top and bottom stones. By means of a hoist of simple construction, consisting in fact only of a large and broad-flanged strap-pulley and a rope-drum, both mounted on the same spindle (the latter being hinged at one end, so that it could be raised and lowered by means of a rope), the sacks of grain or flour could be made to ascend and to descend at pleasure, and the operatives themselves could pass from one floor to any other, by simply tightening and releasing the rope. The shafting of this mill was made of wrought iron, and the wheels, pulleys, hangers, pedestals, frames, &c., of cast iron, much in accordance with modern practice. The castings were from the Grand-Ducal Ironworks.

In 1816, Mr. Bodmer for the first time visited England and Scotland, as previously stated. He had letters of introduction which enabled him to gain access to the principal workshops, cotton-mills, woollen-mills and ironworks. He visited Manchester, Liverpool, Derby, Leeds, Sheffield, Birmingham, Glasgow, Edinburgh, and other places of note, and made himself acquainted, as far as the short time allowed would admit, with the principal features of the various branches of industry in which he took the greatest interest.

Mr. Bodmer left the service of the Grand Duke of Baden about the year 1821, his partnership with Baron d'Eichthal having been previously dissolved. He then returned to Switzerland, and was, amongst other things, engaged by a former pupil of his to design

and partly superintend the erection of a cotton-mill at Aarau, in which his improved machinery was to be introduced. Somewhat later he was also commissioned by the proprietors of the Baths of Schinznack, in the Canton of Argovie, who had it in contemplation to completely reconstruct their establishment, to prepare the plans for the new buildings, as well as for the waterwheel, pumps, and other machinery intended to distribute the water and to supply the various bath-rooms. This was accomplished in such a manner that not only the desired temperature was uniformly maintained, but the sulphurous vapours were kept down to such a level as not to annoy the bathers. This machinery was, it is believed, subsequently carried out by Messrs. Fairbairn and Lillie, of Manchester, to whom Mr. Bodmer showed and explained the drawings on his return to England in 1824.

Almost immediately after his arrival in that country, Mr. Bodmer, having in the meantime further matured and improved the new system of cotton machinery previously adverted to, proceeded to take out a patent (No. 5,016—1824), for the invention. Manchester, as the centre of all operations connected with the manufacture of cotton, was selected as his first place of residence. He soon found out, however, and was indeed assured of it by friends, that considering the total novelty of the system of cotton machinery, and the prejudices entertained against foreigners, as well as against their inventions, especially in a branch of industry so peculiarly English in origin and growth, it would be absolutely necessary, in order to establish the efficiency and superiority of the invention to the satisfaction of those who were expected to make use of it, to exhibit the machines at work in a cotton-mill. Mr. Bodmer, therefore, in partnership with a gentleman of the name of Novelli, to whom he had been introduced, and who appeared to understand and to appreciate the merits of the improvements, determined upon adopting this course. A suitable site was found at Egerton, near Bolton-le-Moors; and in order to be as near as possible to the spot selected for the enterprise, as also to the works where the mill-gearing, machinery, &c., was to be executed, Mr. Bodmer took up his residence in Bolton, with a suitable staff of draughtsmen and assistants. Besides this, however, a temporary building, composed of bricks and planks, was erected at a short distance from the mill, where both Mr. Bodmer and his assistants resided for a considerable time, with a view to facilitate the superintendence and direction of the various operations which were going forward. As both the fall and quantity of water were considerable—equal, in fact, to something like 40 H.P., Mr. Bodmer, in order to utilize the fall to the greatest extent, designed a waterwheel of more than 60 feet in diameter, with a shaft of cast iron, with which the cast-iron shrouding was connected radially, and stayed diagonally, by wrought-iron

rods emanating from cast-iron centres on the shaft. The sheet, or plate-iron buckets were each bent to a curve calculated to receive and discharge the water with the least possible disturbance and loss. A further and altogether novel feature of this waterwheel, the plans of which are still in existence, consisted in a peculiar arrangement for providing for the free escape of the air, though not of the water, from the buckets, so as to prevent the disturbance and scattering of the water on its rushing into the buckets as each came round in succession to be filled. An internal wheel, composed of cast-iron segments gearing into a pinion, drove the first motion shaft at a considerable velocity. This waterwheel was partly finished by the well-known Engineers, Messrs. Rothwell, Flick, and Rothwell, of Bolton, when, Mr. Bodmer's health completely failing him, he was obliged to leave England, on which occasion the completion of the whole was intrusted to Messrs. Fairbairn and Lillie. For the purpose of facilitating the operations connected with the erection of the building, waterwheel, &c., Mr. Bodmer, without being aware of the previous existence of such an apparatus—if indeed the invention was not then a new one—constructed what is now called a 'Travelling Crane.' On his return to the Continent, in 1828, and after having recruited his health by a stay of some weeks' duration at the Baths of Pfeffers, in Switzerland, Mr. Bodmer, at the request of Messrs. Hartmann, of Munster, in Alsace, the well-known proprietors of extensive cotton-mills and dye-works, undertook to prepare plans of the new system of cotton machinery, which had also been patented in France, with a view to its introduction into their cotton-mills; and with one or two assistant draughtsmen, went to reside at Munster for a considerable time, for the purpose of directing and superintending the operations. He subsequently spent some time at Zurich, where he continued to further improve his cotton machinery, and also designed a flour-mill, and a blast, or smelting furnace of novel construction.

At the invitation of the Municipality of Geneva, Mr. Bodmer gave in a plan for a bridge over the Rhône, intended to connect two opposite quarters of the town, and in acknowledgment of his services, was presented with a handsome silver salver, bearing a suitable inscription. In 1830, Mr. Bodmer spent some time at Geneva, where he had several friends, amongst them Mr. Fazy-Pasteur, Mr. Martin, and Mr. Duval. The latter had recently come into possession of a small ironworks at Ardon, in the Canton de Valais, and as he wished to have Mr. Bodmer's advice and assistance respecting the most urgent alterations and improvements for putting the place into tolerable working condition, Mr. Bodmer willingly consented to spend a few weeks at these works; whence he returned to Zurich.

During his stay in Alsace, Mr. Bodmer had made the acquaint-

ance of Messrs. de Dietrich, the proprietors of several ironworks in the Department of the Lower Rhine, the principal one of which was situated at Niederbronn, a small town about 30 miles from Strasbourg. Owing chiefly to the somewhat antiquated character of the machinery employed, these ironworks were not, at the time in question, yielding as profitable a return as, in consideration of their favourable situation with regard to fuel and ores, they might have done. Mr. Bodmer was therefore called in and requested to suggest such alterations and improvements as he might consider necessary, or desirable. It was subsequently found that Mr. Bodmer's presence at or near the works would be both more convenient and satisfactory; and he was accordingly invited, about the year 1831, to take up his residence at the then abandoned ironworks of Reichshoffen, situated at a distance of only a few miles from Niederbronn, and about the same distance from another ironworks belonging to the Messrs. de Dietrich. For greater convenience in carrying out the work of improvement then contemplated, a portion of the existing buildings was converted into a smiths' shop, fitting and turning shop, patternmakers' shop, and drawing office; whilst two large sheds served as erecting shops for heavy machinery, and the workmen's cottages were restored to their original use. A new waterwheel for driving the fans, lathes, &c., was also erected, the power to work it being supplied by a stream of water running through the premises. New blast-engines were in the first place designed and constructed for two of the ironworks; and as these were to be actuated by waterwheels, and no machinery for boring out iron cylinders being at hand, the vessels for receiving and discharging the air were simply square wooden boxes, open at the bottom, and with the sides and top strongly jointed together and bound and tied by iron bars. There was, of course, a square piston, also made of wood, except as to its attachments to the piston rod, fitted with a number of springs acting upon adjustable and overlapping pieces of wood which represented the piston rings. The piston was actuated by a lever, one arm of which was connected with the piston rod, whilst at the extremity of the other arm there was a toothed segment, acted upon by a wheel armed with teeth over a portion of its circumference only, and which therefore alternately depressed and released the segment, thus causing the piston, which was counterweighted, to rise and to descend. During the descent of the piston a valve opened, admitting the air into the box, which air was compressed and expelled by the upstroke. There being two such boxes, or air vessels, the piston of the one was caused to descend whilst the other ascended; so that the action of the machine was sufficiently uniform. One of these blast engines was kept continuously at work for more than fifteen years, and answered its purpose remarkably well. These and other minor

improvements and alterations having been carried out, Mr. Bodmer designed and subsequently constructed at Reichshoffen, a mill for rolling bars and a machine for cutting nail rods, which, besides being fitted up in a superior style, embodied many novel features. But it so happened that after this mill had been erected, the manager or director of the ironworks was unable to recognize either the novelty or the superiority of it, and persuaded Messrs. de Dietrich to authorize him to substitute a mill of his own scheming. As the arrangements of the workshops of Reichshoffen, although moderate in extent, were sufficiently large to admit of the execution of other machinery besides that required for the surrounding ironworks, Mr. Bodmer undertook the construction of a waterwheel, shafting, gearing, hangers, pedestals, &c., for a cotton-mill and weaving-shed then recently erected at the village of Uster, near Zurich; and the contract was carried out to the satisfaction of both parties.

As the French government frequently gave Messrs. de Dietrich large orders for cannon balls and shells, in the dimensions of which but a trifling deviation from the true diameter was allowed, Mr. Bodmer not only had most accurate and convenient iron patterns made; but, moreover, introduced an apparatus for the use of the moulders, by means of which these patterns could be drawn out of the sand with the greatest ease and accuracy.

There being now no further necessity for Mr. Bodmer's presence at Reichshoffen, he determined upon returning to England, and arrived there in the summer of 1833. After a short stay in London, he proceeded to Manchester, and then appointed Messrs. Sharp, Roberts, and Co., under agreement, to be the makers of his improved cotton machinery, which they also undertook to recommend and to introduce to the best of their ability. Their exertions were, however, only successful in one or two cases, and the agreement was, not long afterwards, cancelled by mutual consent. In the following year Mr. Bodmer returned to Bolton, where—at the works of Messrs. Rothwell and Co., the Union Foundry—the patterns and machinery left behind on his departure from England, in 1828, had been kept, and where he hired a floor, which was speedily fitted up as a workshop. In May, 1834, Mr. Bodmer obtained two patents (Nos. 6,616 and 6,617), under the respective titles of "Certain Improvements in Steam Engines and Boilers applicable both to Fixed and Locomotive Engines," and "Certain Improvements in the Construction of Grates, Stoves, and Furnaces, applicable to Steam Engines, and many useful purposes." The main features of novelty in regard to the steam-engine consisted in its being fitted with two pistons moving simultaneously in opposite directions, and connected with a double crank: the steam being alternately admitted between the pistons and near the cylinder ends. The advantage of this peculiar arrangement was, that the

thrust and strain occasioned by the pressure of the steam was exclusively sustained by the cylinder and by the cranks, and could not affect either the foundation and frame, or the bearings of the crankshaft of the engine; admitting, therefore, of a high speed, without entailing that wear and tear which takes place in steam-engines of the ordinary construction, and reducing the corresponding piston speed to one-half. Mr. Bodmer immediately proceeded to construct a non-condensing engine upon this double piston or compensating principle, which was also further provided with a mechanism for reducing the pressure upon, and, therefore, the friction of, the slide valve. This consisted simply in a piston placed in a cylinder at the back of the valve box, and connected with the slide valve by a link; so that the steam exerted its pressure simultaneously against the slide valve in one direction, and against the piston in the opposite direction. This first specimen of the double piston engine, after being finished, was simply bolted to posts in the middle of the workshop; and although the cylinder was at least 10 inches in diameter, and allowed to revolve at a speed of more than one hundred revolutions per minute, there was no perceptible shaking or vibration in any part of the building, which was a very old one. It was Mr. Bodmer's idea, that although taking mere size into consideration, the compensating or double piston engine was slightly, perhaps considerably, more expensive than the ordinary one, owing to its requiring a double set of pistons, piston-rods and connecting-rods, as well as a double crank; still, in consequence of the great speed admissible, the engine could be made much smaller and lighter, and the foundations much cheaper, so as to compensate for the additional outlay. But the parties to whom Mr. Bodmer intended to confide the manufacture of these engines declined to become the makers of them or to recommend them, on the plea that through their introduction, the profits of the iron foundry would be curtailed. It is probable that there were other reasons for this refusal; but however that might have been, as the cotton-spinners and others could not see their way any more clearly than the engineers, they talked of complexity of construction, of the dangers of high speeds, and declined to run the risk of patronising so daring an innovation, especially as it emanated from a foreign engineer, who could not be supposed to be an authority in the article of steam engines.

The construction of the fire-grates was based upon the principle, that in order to attain the greatest possible degree of economy in the combustion of pit coal, it was desirable to supply the furnace with fuel at a slow rate, but uniformly and continuously. These considerations led Mr. Bodmer to the adoption of a travelling grate surface, in combination with a hopper and a sliding door, for regulating the depth of the layer of fuel. This object was purposed to

be accompanied either by connecting the grate bars after the manner of links of a pitched chain, passing in front and at the back over a chain drum, one of which drums might either be driven by hand or by power; or by placing removable bars so as to form the circumference of a revolving drum; or else by moving the bars either singly or in sets towards the bridge, dropping them at the bridge end, and causing them to return to their original position by suitable mechanism. It was Mr. Bodmer's intention to have conducted a series of experiments with the moveable-bar grate, and the greater part of the mechanism, as well as a suitable furnace, had already been constructed; but owing to a variety of circumstances these experiments were postponed, or in fact altogether abandoned.

Mr. Bodmer had, in the mean time, still further modified and improved his cotton machinery, chiefly in regard to the mode of winding up the product of the carding-engines, drawing-frame, and slubbing-frame, in which flanged bobbins of any convenient size were substituted for those described in his patent of 1824: the slivers or rovings being laid on to the bobbin by means of tubes or guides fixed upon a slide, to which a reciprocating motion was given. As the periodical stripping of all the top-cards or flats of a carding-engine, by hand, in the usual manner, causes an unequal thickness of the fleece, Mr. Bodmer, after having already, in his patent of 1824, shown a self-acting apparatus for stripping the top-cards one by one, in regular succession, whereby the operation was always performed upon the flat nearest to the licker-in, which was subsequently carried to a position nearest to the doffer, whilst the remaining top-cards were being simultaneously moved backwards towards the licker-in—still further improved and simplified this important mechanism. Another improvement relating to the carding-engine, which, after having been re-invented, was, as an infringement upon Mr. Bodmer's prior rights, adopted to some extent by the cotton-mill owners, consisted in a sharp-edged plate, closely interposed between the feed-roller and licker-in, in such a manner that the feed-roller held the cotton, whilst the licker-in acted upon it. The fibres were thus bent and drawn down over the edge of the plate, and thereby more thoroughly separated and cleansed, at the same time that the feeding was more regular, and the cotton prevented from forming into lumps. These, and other improvements and modifications, were subsequently embodied in a patent, under the title of "Certain Improvements in Machinery for Preparing, Roving, and Spinning Cotton and Wool" (No. 6,841, 1835)—various experimental machines having been previously constructed and tried.

It was about this time that the formation of a railway between London and Birmingham being in contemplation, Mr. Prevost,

of London, one of the directors, invited Mr. Bodmer to give his views as to the best system of rails and carriages. On this occasion Mr. Bodmer proposed the construction of carriages since adopted in the United States of America, in parts of Germany, and in Switzerland, and the distinctive feature of which is, that there is a longitudinal passage through the middle of each carriage, so that the guard can pass from one end of the train to the other with the greatest ease and security.

It had long been Mr. Bodmer's idea, that the mechanism for actuating self-acting mules ought to be placed altogether apart from the mule, and to be capable of simultaneously operating upon two, or any desirable or convenient number of, spinning machines. With this view he planned a self-contained machine, intended to be connected with the mule only by such articulations as the command over the motions of the carriage, rollers, and fallers required. This machine was actually constructed and experimented upon with such success as could reasonably be expected to attend so novel a combination of mechanism. Mr. Bodmer's new system of cotton machinery was to some extent carried out at the mills of Messrs. Bolling, of Bolton. There were also one or two cases of infringement upon small portions of Mr. Bodmer's patents, one of which, at least, was settled by arbitration; the late Mr. Benjamin Hick, a highly valued friend of Mr. Bodmer's, being the arbitrator.

In 1837, Mr. Bodmer took out a patent under the title of "Certain Improvements in Machinery for Spinning and Doubling Cotton, Wool, Silk, Flax, and other Fibrous Materials" (No. 7,388). The principal feature of novelty consisted in a peculiar flyer or guide, whereby, in combination with suitable machinery, the yarn was to be wound upon the bare spindle, in the form of 'pincops,' as in an ordinary mule for spinning. An experimental machine with two spindles was first constructed upon this plan, and it was found that the principle of winding upon the bare spindle by such means was quite correct; but great difficulties were experienced in selecting the proper material from which the flyer was to be made, and a great deal also depended upon the size and shape of this flyer. It was found that sheet iron, or sheet steel was too heavy; wire was apt to get out of shape and to become entangled in the guide-box, and paper and parchment were affected by heat and moisture. A machine containing about the same number of spindles as ordinary 'throstles' was a considerable time afterwards constructed and experimented upon; but sufficiently satisfactory results could not be obtained with the materials for the construction of the flyers at command, and the machine was, therefore, laid aside. There was, however, no difficulty in spinning flax.

Towards the latter part of the year 1837, Mr. Bodmer made the acquaintance of the late Mr. Hugh Hornby Birley, of Man-

chester, who, thinking highly of Mr. Bodmer and his inventions, and being willing to furnish the means of having these inventions carried out, proposed that Mr. Bodmer should transfer his tools, patterns, and machines to Manchester, where, at the Chorlton Mills, belonging to Messrs. Birley and Co., a large room on the ground floor was placed at his disposal; to which was, some time afterwards, added another room of about the same size. At a somewhat later period, a foundry situated at a short distance from the mills, was purchased by Mr. Birley, to which, by altering and repairing existing buildings, and erecting new ones, a pattern-makers' shop, carpenters' shop, fitting-up shop, blacksmiths' shop, and grinding-shop were added, besides a counting-house, drawing-office and storerooms. The power for driving the blowing-fans and other machinery was supplied by one of Mr. Bodmer's patent compensating condensing steam engines. The boiler furnace was also fitted with one of the patent revolving drum-grates, which, however, was not found to answer the purpose as well as had been expected; and as it would have been inconvenient to try further experiments with it, it was subsequently removed, and an ordinary grate substituted for it.

In 1838, Mr. Bodmer took out a patent under the title of "Certain Improvements in Machinery or Apparatus for Carding, Drawing, Roving, and Spinning Cotton, Flax, Wool, Silk, and other Fibrous Substances" (No. 7,837), a schedule of which machinery and apparatus is annexed to this Memoir. It may, however, not be uninteresting to advert more particularly to a modification of the detached self-acting spinning-machine, of which mention has been previously made, as contained in the above patent. One of the principal features of this machine, both in its original and its modified form, and by means of which the movements of the carriage were regulated, consisted in a pair of cones, of which the driven cone was fitted with internal gearing in communication with the loose central shaft; the respective diameters of these cones and the wheels being so proportioned, that when the driving-strap was placed in a certain position, say in the middle of the two cones, the central shaft remained stationary; whilst on moving the strap to one side of that position, the central shaft turned in one direction, and on moving it to the opposite side, the said shaft turned in the opposite direction; the number of revolutions of the central shaft increasing, in each case, as the strap was moved nearer to the end of the cone. It is evident that a change of motion could thus be effected gradually and gently, which is a feature of great importance in spinning machinery. In the machine under consideration the drawing out and putting up of the carriage, and the afterdraft were controlled by this central shaft.

The whole of the machines described in the above Patent, with

the exception only of the one last mentioned, were actually made and tried ; although for various reasons, which it would be out of place here to specify, they were not adopted.

As it now became necessary to furnish the new workshops with suitable machine-tools ; and, as in Mr. Bodmer's opinion, the lathes, planing-machines, and other tools which were to be had at that period were not sufficiently strong, accurate, and convenient, he set himself the task of designing a variety of tools, some of which were completely novel, whilst others, in principle already known, were by him improved, and new features of usefulness added to them. A patent taken out in 1839, and entitled, "Certain Improvements in Machinery, Tools, or Apparatus for Cutting, Planing, Turning, Drilling, and Rolling Metal and other Substances" (No. 8,070), embodied the improvements above referred to. Gradually, nearly the whole of these tools were actually constructed and set to work. The small lathes, the large lathes, and the planing, drilling, and slotting-machines were systematically arranged in rows, according to a carefully-prepared plan ; the large lathes being provided, overhead, with small travelling-cranes, fitted with pulley-blocks, for the purpose of enabling the workmen more economically and conveniently to set the articles to be operated upon in the lathes, and to remove them after being finished. Small cranes were also erected in sufficient numbers within easy reach of the planing-machines, &c. ; besides which several lines of rails traversed the shop from end to end, for the easy conveyance on trucks of the parts of machinery to be operated upon. Such arrangements were not common in those days, whatever may be the case now.

With regard to the wheel-cutting machine, which was an efficient and accurate, as well as a larger and more complete machine than those generally employed for this purpose in 1839, it will be proper to mention, in this place, that Mr. Bodmer had, for years, been in the habit of tracing the shape of the teeth of wheels by means of two segments of wood, representing respectively the pitch lines of the two wheels which were to gear into each other. To these segments pieces of tin plate, on which the pitch line, thickness and height of the intended tooth were marked, were fixed by tacks or screws ; when the upper and lower curves were successively traced by means of an adjustable style, by rolling the circumferences of the two segments against each other. This system was pursued equally with regard to the teeth of spur-wheels, bevel-wheels, worm-and-worm-wheels, and racks and pinions, and with the most satisfactory results, as the wheels so constructed, whether on a large or on a small scale, worked noiselessly and smoothly, and with a minimum wear and tear. It is believed that this system is now almost universally adopted, although when Mr. Bodmer came to England, in 1824, it was quite unknown.

Mr. Bodmer approved so highly of the French metrical system of measures, that he adopted it, and made use of it in all his drawings and constructions. He also, from the first, introduced it into his workshops in England; and so far from experiencing any difficulties in this matter, on the part of the men, they understood it immediately, and liked it, at least, as much as the duodecimal system represented by the old foot-rule, and the subdivision of the inch into 'eighths,' 'sixteenths,' and 'thirty-seconds.' A number of wooden staves of half a metre in length, accurately marked and divided by a machine made expressly for that purpose, into decimetres, centimetres, and millimetres, were distributed amongst the workmen; and although they would frequently, by way of abbreviation, call a 'millimetre' a 'metre,' the misnomer did not lead to any errors. For the use of the pattern-makers, the measuring staves were divided so as to include an allowance for the contraction of the metal; that allowance never being left dependent upon the private judgment of the men. Besides, there was in existence, and accessible to the workmen on application to the foreman, a complete system of distinctly marked and accurately executed internal and external gauges of various kinds, so that any required measure could be tested, either directly, or by means of the callipers, if required.

Based upon the metrical system of measures, Mr. Bodmer had long ago adopted a denomination of the pitches of wheels, which differed materially from the denominations in use elsewhere. Instead of calling the distance between the centres of any two teeth on the pitch line, the 'pitch,' from which the diameter of the wheel could be ascertained, by multiplying the number of teeth with the pitch, and subsequently dividing by 3.1416, Mr. Bodmer called his pitches I., II., III., IV., &c.; and the number of teeth, multiplied by this pitch, gave at once the diameter of the wheel in millimetres. For instance, the diameter of a wheel IV. pitch, with thirty feet, was $4 \times 30 = 120$ millimetres; and the actual distance between the centres of any two teeth, on the pitch line, would, of course, be $4 \times 3.1416 = 12.57$ millimetres nearly, or about $\frac{1}{2}$ inch. This system possesses the great advantage, that the diameter of the wheel can be immediately ascertained from the number of the teeth, by means of simple multiplication, and that it has never to be expressed in any fractional part of a millimetre. It is now called, it is believed, the 'Manchester Pitch,' though it has only become so since Mr. Bodmer was in Manchester.

With a view to the greater uniformity, accuracy, and rapidity of execution of the work, both in the drawing-office and in the workshops, Mr. Bodmer had a number of tables prepared, which represented, both graphically and descriptively, the shape, dimensions, and particulars of the screwing-stocks, dies, and taps, and wrenches: of the

heads and nuts of screws and bolts for various purposes ; of screw-keys of various kinds ; of the keys required for keying wheels and pulleys on shafts ; of the drills and boring tools for various purposes ; of the pedestals and brasses for various sizes of shafts, &c. After the general drawing of any machine had been made, the parts for which patterns were required, and those which had to be made in the smiths' shop, were drawn out on separate sheets of paper, with all the dimensions accurately marked in millimetres. These drawings, upon being completed, were mounted on pasteboard, varnished, and afterwards given into the hands of the respective foremen. After the smiths and pattern-makers had done their part, the drawings were passed into the turning and fitting-up shops, together with the general drawing. The whole of the drawings were numbered consecutively, and these numbers, with description, were entered in a book kept for that purpose.

The pentagraph had never, previous to the date of Mr. Bodmer's patent, been applied, it is thought, as a shaping and cutting tool for metal ; a few observations respecting its construction and functions may, therefore, not be out of place. It was intended for turning, shaping, and grooving cutters, to be used in cutting the teeth of metal wheels ; and it effected these operations with great facility and accuracy, by means of a guide and template on an enlarged scale, which latter determined the shape of the cutter, as fixed to the spindle of a headstock through the instrumentality of stationary and rotating cutting tools respectively. In order to admit of the construction of cutters of comparatively large dimensions, without running the risk of their warping or breaking in the hardening, they were each composed of six equal segments, made with projections to form a boss about the centre, to be grasped by two box-rings ; one of which formed part of the spindle for holding the cutter, whilst the other was removable, and could be tightened up against the cutter by means of a nut. The pentagraph headstock was so arranged, that, after the cutter had first been bored, turned, faced, and roughly shaped on the lathe, the exact contour could be given to it on the pentagraph by allowing the spindle, with the cutter mounted on it, to revolve, whereupon a small tool, with a conically-shaped head, and connected with the short limb of the pentagraph, was brought into action against the cutter. This operation, having been accomplished, the headstock spindle was connected with a dividing apparatus, by means of which, and by causing a conically-shaped and milled tool of precisely the same dimensions as the one above mentioned, but revolving rapidly instead of being stationary, to act upon the cutter under operation ; the latter was, at suitable and equal distances, provided with the requisite grooves. The finished cutter was, thereupon, marked with the number of pitch, &c., and subsequently hardened, each segment

by itself, in which process oil was used for the purpose of obtaining a uniform temper. By means of such cutters the whole of the change wheel patterns were cut; and for whatever other purposes cutters might be wanted, as, for instance, for shaping nuts, for cutting grooves, in screwing taps or otherwise, they were made in precisely the same manner: the enlarged template, previously referred to, insuring, of course, great accuracy and uniformity as to shape. There was also an apparatus connected with the pentagraph by means of which screw-cutters for cutting worm-wheels could be shaped; and many such, of beautiful workmanship and great efficiency, were so made.

Another machine which deserves particular mention, was the 'Circular Planing Machine,' in all respects similar to the ordinary planing machine, except that it had a circular horizontal table, which revolved in V grooves on a cylindrically-shaped bed, besides being supported by a vertical spindle, by means of which it could be raised out of contact with the grooves, and thus caused to revolve at an increased velocity. This machine was used for planing or turning heavy wheels, as well as for boring them, being likewise provided with a self-acting boring bar, which could be placed in and out of gear, at pleasure. This convenient machine-tool was, however, equally well adapted for facing the ends of steam-engine cylinders, and for operating upon other articles too inconvenient in shape to be dealt with by a lathe, or ordinary planing machine.

The grinding, equalising, or polishing machines, of which several were in operation at Mr. Bodmer's workshops, were of great service in all cases where any surfaces, whether flat or cylindrical, had to be equalized and polished. A machine of this description, fitted with a copper disc of about 3 feet in diameter, mounted on a horizontal spindle, and revolving at a great velocity, was, for a considerable time, chiefly employed in operating upon rollers or cylinders of 10 inches in diameter, and 15 inches in length, which were required by Messrs. Macintosh and Co. in the preparation of India-rubber. These rollers were made of cast iron, chilled; and it was absolutely necessary that they should be, throughout, of precisely the same diameter, and that their surfaces should be perfectly true and smooth; and the result was invariably all that could be desired. In connection with these rollers, it may here be mentioned that Mr. Bodmer made the plans and drawings for, and executed at his works, a whole series of machinery for the preparation of caoutchouc, to the order of Messrs. Macintosh and Co.

Another machine of the same kind, but fitted with a copper disc mounted on a vertical spindle, was used in operating upon the surfaces of lathe beds or other metal surfaces, with a view to the usual scraping being dispensed with. In this machine the bearings of the spindle were held by a radial arm, which was both horizon-

tally and vertically moveable and adjustable, whilst a vibrating motion was communicated to the table upon which the object to be operated upon was placed. The disc of the above first-mentioned machine, however, was mounted on a slide, horizontally adjustable on a suitable bed, and the article to be equalized was also mounted on slides, whereby it could be moved both horizontally and vertically, and brought closer to or removed further from the disc. In the case of rollers or cylinders, they were mounted on the slide in bearings, and a rotatory motion could be imparted to them. Besides these special machines a variety of smaller discs, mounted either on slide rests or on independent frames, were used, for 'bracing up' case-hardened spindles, journals of shafts, cylindrical case-hardened gauges, and for other purposes, in every case proving most useful and valuable auxiliaries.

With regard to the mills for rolling tires for wheels and hoops for boilers, which stand last in the list of inventions contained in the Patent of 1839, it may be as well to observe in this place, although the transactions to be referred to occurred many years later (about 1845), that both Mr. Birley and Mr. Bodmer gave themselves much trouble in endeavouring to induce some manufacturers of iron, who were at the time in the habit of supplying tire-bars to the makers of railway rolling stock, or some of these makers themselves, to give the tire rolling mill a trial. Accurate and expensive working models were prepared, and tires of lead actually rolled in them, so as to give a clear idea of the working of the machine; and it was explained what a great saving in material would be effected, owing to the fact that such tires would require no subsequent turning on the lathe; that, in the case of engine tires, certainly, the rolling would involve much less expense than the turning, and that finally the tires would be more durable, on account of the harder skin left by the rolls. But it was impossible to overcome the prejudices of ironmasters and engineers by any such arguments. At last Mr. Peter Rothwell Jackson, of Bolton, who had entertained a favourable opinion of the invention from the time when his attention was first directed to it, decided upon taking a licence from Mr. Bodmer, in conjunction with Mr. James Hardcastle, of Firwood. Mr. Jackson and Mr. Hardcastle accordingly erected, in Salford, near Manchester, a tire rolling mill embodying, in substance, various improvements secured by Mr. Bodmer in two subsequent patents. Many practical difficulties had to be overcome before the manufacture of the tires could be systematically and economically carried out: and after that it required great perseverance, much reasoning, and a vast accumulation of facts, before contractors and railway companies could, except in isolated instances, be induced to use the rolled tires. After a short time Mr. Hardcastle retired, and left the business altogether in Mr. Jackson's hands. The latter, on the

expiration of the Patent of 1839, in 1853, through Mr. Thos. H. Birley, the son of the late Mr. Hugh Hornby Birley, applied for, and obtained a prolongation; but previously to that time he had, and he has since then obtained several patents for improvements made for himself in tire rolling mills. The opinions of railway engineers, contractors, and others in the habit of using tires, have since undergone such a remarkable change, that tire rolling mills have now sprung up all over the country. Until very recently no attempt has been made to carry out the rolling of hoops for boilers; but there can be no doubt that this second branch of the invention will, in the end, prove as important as the first.

At Mr. Jackson's works the rolling-mill was driven by a non-condensing high-pressure steam-engine of 30 H.P., constructed upon the inverted cylinder compensating or double piston principle. These engines are described in Mr. Bodmer's Patent No. 8,981, of 1841, and they have, as their name implies, the crank-shaft mounted in bearings fixed to the frame or sole plate. A certain number of engines of this kind, some being of 8 H.P., some of 30 H.P., and some of 60 H.P., were made at various times and set to work: the 60 H.P. engines chiefly at some of the bleachworks near Bolton; but one of them, as well as one of 30 H.P., at the works of Messrs. Macintosh & Co. A 30 H.P. condensing engine was also erected at the works of Messrs. Sharp, Roberts, & Co., and intended to drive the tools, &c., forming part of a recent extension of their establishment. The crank-shafts of these steam-engines were made of cast iron, and the foundations consisted of a few feet of brickwork, the sole-plate resting upon stone slabs. The speed of the 60 H.P. engines was about one hundred and twenty revolutions per minute, and it was constantly maintained, without the least inconvenience or difficulty. One of these engines, erected at the bleachworks of Mr. Horridge, near Bolton, was regulated by a governor acting upon a throttle-valve in the exhaust-pipe, which prevented the egress of the steam, and therefore instantaneously checked the speed of the engine. This governor was described in a Patent of Mr. Bodmer's, No. 10,243 of 1844; but it was afterwards found that, in principle, it had been known before.

As Mr. Bodmer's partially successful efforts to introduce his compensating or double-piston steam-engines at bleachworks have been referred to, it may be mentioned that Mr. Bodmer had, previously to 1833, already invented, in connection with some of his improved cotton machinery, a simple and efficient apparatus for connecting and disconnecting machinery with the driving-shaft, without producing those sudden shocks which were unavoidable with the clutch-boxes and other similar contrivances then in use.

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Several improvements upon this primitive apparatus, adapting it for use in connection with the most powerful machinery, were patented by Mr. Bodmer in 1843 and 1844 (Patents Nos. 9,702 and 10,243) respectively; and as it appeared particularly desirable that the action of the mechanism for stopping and starting bleachers' 'mangles' and callenders should be perfectly smooth, Mr. Bodmer recommended his Patent Starting Apparatus, or Break, as it was generally called, to Mr. Thomas Ridgway Bridson, of Bolton, who at once consented to have it introduced at his bleach-works, where one of the 60 H.P. compensating engines was already at work. It answered its purpose remarkably well, in connection with one of the large mangles, enabling the attendant to stop and start the machine at the precise time required, without the least damage to the goods under operation, and without any noise whatever. In the apparatus here referred to the desired effect was produced by tightening or releasing a strap, which acted as a friction break upon the external circumference of an internal wheel, which latter was connected by other wheels both with the motor and with the machine to be set in motion and controlled. In other cases the Starting Apparatus acted simply through the friction between a number of segments, connected with a sleeve by means of togglejoints, and lined with copper, against an internal drum mounted upon a shaft in connection with the motor: the sleeve or sliding bush being mounted upon the shaft to be set in motion and disengaged, as might be required. Starting Apparatus of both kinds, and which, owing to their peculiar construction, would, in case of the machines connected with them meeting with undue resistance, yield to the force applied by the motor, were subsequently also adopted by Mr. Horridge and others. In some of the bleachers' mangles which Mr. Bodmer constructed at his works he introduced self-adjusting bearings of superior hardness; but the principal improvement consisted in making the brass 'bowls' of a superior kind of alloy. These bowls, after having been 'roughed out' on the lathe, to nearly the finished size, were submitted to the operation of a narrow milling tool, which, being placed in the slide-rest, was made to pass along the whole length of the bowl, strongly compressing the metal on its surface, whereupon the finishing cut was given. Bowls so treated proved more efficient and durable than those in common use.

Mr. Bridson consented, at Mr. Bodmer's request, to let three steam-boilers be fitted with the improved firegrates which Mr. Bodmer had patented in 1843 (Patent No. 9,899). In these grates the firebars were actuated by screws, similarly to the 'gill bars' of flax-machines. These screws, made of cast iron, were placed in suitable frames and bearings underneath and at a suitable distance from the boiler, as much as possible out of reach

of the fierce heat of the fire, and connected by means of worms and wormwheels, or other gearing, by which they were caused to revolve in opposite directions, propelling the firebars towards the bridge. Arrived there the bars were, by a suitable apparatus, guided down into the threads of the lower or return screws, and on arriving in front, each bar was, in succession, once more raised to the level and under the action of the top screws. A hopper, fitted with an adjustable sliding door, was placed over the firebars, in front; and as the firebars moved slowly towards the bridge, the fuel, descending from the hopper, was of course compelled to move with them, covering the bars to the depth corresponding with the opening of the sliding door. The top screws were, however, so constructed that near, and to some distance from the hopper, in the direction of the bridge, up to which point the fuel must be supposed not to have become as yet fully ignited, the firebars lay very close together, so as to prevent the small coal from falling through; whilst from that point onwards the threads of the screw became more and more 'drunken' and further apart, thus causing the firebars to rock backwards and forwards, and any clinkers that might have formed upon them to break off (if not preventing the formation of clinkers altogether), and, besides, admitting a greater body of air for the support of the combustion. The threads of the screws then gradually returned to their regular shape again, and at that distance from the bridge where the fuel might be supposed to have become to a great extent consumed, the distance between the bars was once more contracted. It was at first found almost impossible to keep the fuel in a state of ignition near the firedoor; but this defect was completely remedied by arching over the entrance to the furnace with firebricks. These grates answered very well in principle, as, besides admitting of the utmost regularity of firing, with which operation the fireman could not interfere, and which prevented the formation of smoke almost altogether, the smallest slack could be used with advantage. Upon testing one of these screw firegrates, in its usual working state, against a common grate fitted to an adjoining boiler of precisely the same dimensions, it was found that by burning large coal in the latter, and using every possible precaution as to the closing of dampers, keeping a thin layer of coal upon the bars, cleaning the spaces between the latter, &c., which under ordinary circumstances it would never have occurred to the fireman to observe, the two grates were about equally effective; almost identically the same quantity of water being evaporated in each with a given weight of fuel. But as the screws, although protected, as has been observed, as much as possible, were still exposed to a great degree of heat, which precluded the use of lubricants, both the screws and the bars wore out rapidly; and after this wear and

tear had once proceeded to a certain extent, the bars became displaced, got jammed in between the threads of the screws, and then broke. It also, sometimes, happened, that between the Saturday evening and the Monday morning following a piece of iron or stone got accidentally mixed with the coals, which substances the grates were not calculated to deal with; and on such occasions a break-down would naturally occur. As the firebars, during their return from the back to the front, had time to cool, being exposed to a strong draft of air for a considerable time; and as, moreover, not one of the bars was constantly subjected to an intense degree of heat, they had not often to be changed or replaced by new ones.

In 1841 Mr. Bodmer took out a patent (No. 8,912) for "Certain Improvements in the construction of Screwing Stocks, Taps, and Dies, and certain other Tools or Apparatus or Machinery for cutting and working in Metals." As will be seen from the annexed Schedule, the Screwing Stocks, Taps, and Dies constituted one of the principal features of this Patent. In order to constitute the die a real cutting tool, and thereby to render it effective with a smaller expenditure of power, as well as to avoid the elongation of the screw which generally occurs when ordinary dies are used, Mr. Bodmer conceived the idea of giving to the die a very small but sufficient amount of lateral play; so that, whether it were acting from above downwards, or from below upwards, it should at all times present a real cutting edge to the screw under operation; thus avoiding all unnecessary friction, and leaving space for the shavings (in this case real shavings) to detach themselves without interfering with the action of the tool. With the purpose of attaining a similar result in regard to the taps, Mr. Bodmer, instead of merely 'backing off' the external circumference of the screw-thread, conceived the idea of relieving each cutting segment of the tap in such a manner as to make the section of each segment, at its largest diameter, the cutting edge, the remaining portion acting merely as a guide. This was accomplished by means of a lathe expressly constructed for the purpose, and in which the motion of the slide-rest, holding the tool, was regulated by a template representing the section of the tap on an enlarged scale. To save trouble the diameter of the circle circumscribing the six-sided heads of these taps was made to correspond with the internal diameter of the tap, so that it could be dropped through the nut after the cut had been accomplished. Screwing stocks, taps, and dies of this description were in constant use at Mr. Bodmer's workshops, and were found to work freely and accurately. Many years later, however—in fact, only a few years before his death—Mr. Bodmer made still further improvements in this description of tools—more especially in the screwing stocks—as well as in the lathe for manufacturing and shaping the taps.

The chasing tools, so that they might combine efficiency and strength, were constructed upon similar principles. Each tool consisted of a segment, adjustable and capable of being firmly fixed in a holder of corresponding shape, the handle of which could be firmly secured in the slide-rest. It could be brought to bear upon the screw to be operated upon in a manner analogous to that of the tap and the nut, and ground and re-set without any trouble, and with the greatest accuracy.

The crank lathe, fitted as it was with a peculiar kind of slide-rest for turning the journals, was found exceedingly valuable in dealing with the cranks of the compensating or double piston steam-engines. The centre chucks, in which the jaws were made to advance towards and to recede from the centre simultaneously, by means of a central wheel, actuated by the spindle of the fast headstock, in which it was recessed, and in its turn acting upon three pinions mounted upon the screws which regulated the motion of the jaws, were applied to many of the lathes, and found most useful. An improved universal joint, fitted with ball and socket as the means of admitting of a deviation from the straight line in one direction, and with strong swivel pins to render such deviation possible in the other direction, was subsequently successfully applied, as a connection between the starting apparatus, or friction breaks formerly described, and the driving bowls of bleachers' mangles. Acting upon the principle that turning is cheaper than any other kind of work, Mr. Bodmer designed a peculiar construction of the heads of the connecting-rods for his steam-engines, which consisted in turning the same externally, and boring them internally for the reception of the brasses; the straps being, of course, also bored out internally, and, after having been placed in their proper position, turned externally. For this internal turning, or boring, a tool was purposely constructed and claimed in the same Patent, by means of which these operations could be performed accurately and expeditiously.

The whole of the tools enumerated in the annexed schedule, referring to the subject-matter of this Patent No. 8,912, with the exception only of the large slotting-machine, with circular table, and the apparatus for rectifying screws, were actually made and used in Mr. Bodmer's works, and were found to answer their purpose remarkably well. Besides these, however, a large radial boring-machine, and a wheel-cutting machine capable of taking in wheels of 15 feet diameter, and of splendid workmanship, especially in regard to the dividing wheel, and a number of useful break or gap-lathes, were also constructed and used with advantage. It is especially necessary to mention a number of small, 6-inch, screwing lathes, which by means of a treadle acting upon the driving-gear

overhead, and a double slide-rest—one of the tools moving into cut as the other was withdrawn,—screw cutting could uninterruptedly proceed both in the forward and in the backward motion of the toolslide, and therefore a given amount of work accomplished in half the time which it would occupy by the use of the ordinary means. Some of the slide-lathes were also arranged for taking simultaneously a roughing and a finishing cut.

It was likewise in 1841 that Mr. Bodmer took out a patent for “Certain improvements in Machinery for Propelling Vessels on Water, parts of which improvements apply also to Steam-engines to be employed on Land.”—Patent No. 8,981. One portion of these improvements refers to a peculiar kind of propeller, consisting, in the main, of a fan revolving in a box; into which latter the water can penetrate through its own gravity, in proportion as it is expelled by the rapid revolutions of the fan, through a short channel, leading from the aforesaid box, horizontally or nearly so, into the water, both ahead and astern of the vessel to which this kind of propeller is applied. These channels were to be fitted with slides or valves, capable of being regulated at pleasure from the deck, by means of hand-spoke wheels and suitable gearing, so as to exclude the water either from the one or from the other, or to contract the openings of either one or both of them, according as it might be desirable to go ahead or astern, to moderate the speed of the vessel in either direction, or to turn the vessel completely round. All this could be accomplished without interfering with the engines, which were to be of the compensating, or double piston principle. Two such fans would be required for each vessel, one to be placed on the port side and the other on the starboard side. Improvements upon these fan-propellers were further secured by Mr. Bodmer in his Patents of 1843 and 1844 respectively (Nos. 9,702 and 10,243); their application to a life-boat being shown in the specification of the former patent. A pair of propellers, with compensating engines, was constructed upon the principle of those represented as applied to the life-boat; the distinctive features of which are that, by simply turning the cylindrical fan-box round its axis, which can be done at pleasure from the deck, the vessel could not only be propelled ahead and astern, but be completely and efficiently steered. One of these fans, with box complete, was placed on a large water-tank, and caused to rotate by means of its own engine; and to judge from the force of the out-rushing stream upon the surrounding water, the effort, if applied to propulsion, must have been satisfactory. Mr. Bodmer was, however, unable to test the apparatus as a propeller; and it was left to Mr. Ruthven to prove, twenty years later, that this kind of propulsion can be carried out in practice. It would nevertheless appear, from the records of the Patent

Office, that fan-propellers and moveable fan-boxes for directing the stream or current of water produced were known previously to the date of Mr. Bodmer's patent.

Recurring again to the Patent No. 8,981, it becomes necessary to mention Mr. Bodmer's Expansion Apparatus, the principal features of which consisted in the expansion-valve rod having a right and a left-handed screw cut upon it, on which the expansion valves—whose position was on the back of the slide-valves—could, by means of nuts forming part of, or attached to them, be made to recede from or to approach each other; thus cutting the steam off at an earlier or at a later part of the stroke. Further improvements in, and modifications of this system of expansion-gear were patented by Mr. Bodmer in 1843 (Patent No. 9,547), and in 1844 (Patent No. 10,243). Mr. Bodmer applied expansion-valves, constructed upon this principle, to all his compensating or double-piston engines; and after the invention had been patented once more by a Mr. Meyer, of Mulhausen, in France, it was adopted by Messrs. Sharp, Brothers and Co., of Manchester, who applied the valves to some locomotive engines, but in a short time abandoned their use, finding them too complicated. On the occasion of this right and left hand screw-expansion valve-regulating apparatus being patented a third time, some years ago, and published as a novelty in one of the scientific periodicals, it was stated, by a correspondent of that journal, that it was then very generally in use in Lancashire; but Mr. Bodmer's name was not mentioned in connection with it; and his expansion gear was also applied to the engines of H. M. Screw Steam Ship 'Amphion' without acknowledgment.¹ In France and on the Continent generally it is known as Meyer's Expansion gear.

Mr. Bodmer contributed two Papers, illustrated by drawings and models, to The Institution of Civil Engineers, during the Presidency of Sir John Rennie, one on "The Advantages of Working Stationary and Marine Engines with High-pressure Steam, expansively and at great velocities; and of the Compensating, or Double Crank System,"² for which he received a Premium,³ and in which communication a description is given of his "Variable Expansion Gear;" and the other, "On the Combustion of Fuel in Furnaces and Steam-boilers, with a description of Bodmer's Fire-grate."⁴

In the Patent No. 8,981, of 1841, and again in the Patent No. 9,702, of 1843, Mr. Bodmer has shown numerous methods of jointing the plates, in the construction of iron ships, in such a manner as to insure, in the first place, perfect uniformity of surface, and in the next place, to increase the strength of the hull.

¹ Vide "The Artizan" for 1853, vol. xi., p. 15.

² Vide Minutes of Proceedings Inst. C.E., vol. iv., p. 372.

³ *Ibid.*, vol. v., p. 2.

⁴ *Ibid.*, vol. v., p. 362.

After having shown the application of his compensating, or double-piston principle to locomotive engines, in his Patent of 1834 (No. 6,616), Mr. Bodmer, in his Patent No. 8,981, of 1841, claims various improvements, which consist, principally, in a peculiar construction of the frame; in the application of spherically-shaped brasses to the ends of connecting-rods; in the use of spherically-shaped axle bearings, and in modifications of the hand gear. Longitudinal sleepers with cylindrico-convex bases, to support broad rails, with a soft elastic substance interposed between the rail and the sleeper, and a broad locomotive engine-wheel tire to run upon such rails, are also described. Further improvements, applying chiefly to the expansion gear, hand-gear, pistons and axle-boxes of locomotive engines, were patented in 1843 (No. 9,702); the axle-boxes being constructed for lubrication with oil, and upon the principle of the ball-and-socket joint, so as to cause them to yield to the unevenness of the road, without binding. The tender is, in this patent, represented with a break which can be made to bear simultaneously upon the wheel and the rail. Again, in Mr. Bodmer's Patent No. 10,243, of 1844, various improvements in locomotive engines and tenders are described and claimed. As regards the locomotive engine, they related to the construction of the fire-box, in which partitions of brass were applied; to the rocking motion of the fire-bars; to the use of four cylinders, two inside and two outside the framing, the former acting upon the crank-axle, and the latter upon crank-pins, and worked by the same slide and expansion-valve; to a peculiar combination of coupling-rods; to the adaptation of air-pumps for injecting air into the boiler; to the construction of brass locomotive engine wheels; to the application of hollow brass piston-rods, &c. As regards the tender, the improvements referred to the feeding of the locomotive engine boiler by pumps placed on and worked by the wheels of the tender, and to the converting of the drag links between the engine and the tender into tubes for conveying the feed-water to the boiler.

Between 1844 and 1846, two locomotive engines, constructed upon the double-piston or compensating principle, and containing many of the improvements above enumerated, as well as two tenders fitted with feed-pumps and skid breaks, were made for and supplied to the South Eastern railway company. These engines were found, on trial, to get up their speed in a remarkably short space of time, and to run without any lateral, oscillatory, vibrating or longitudinal reciprocating motion. But after they, and especially the tenders, had been subjected to a number of alterations, they were, for no assigned cause, withdrawn from the line.

A patent secured by Mr. Bodmer in 1842 (No. 9,279) contained further improvements in the construction of cotton machinery, as enumerated in the annexed Schedule. Another patent, of the same

year (No. 9,279), already alluded to, contained chiefly modifications of the rolling mills for tires, as well as for pulleys and other hoops. The improvements comprised in Patent No. 9,702, of 1843, have already been alluded to. A pumping-engine upon the double-piston principle was made to order; but afterwards, owing to a misunderstanding, countermanded and never tried.

With the exception of an independent or portable boiler, fitted with the screw fire-grate, and the lathe for cutting the 'drunken' screws, the inventions described in Mr. Bodmer's Patent No. 9,899, of 1843, were never carried out. But it deserves to be mentioned that the band-saw, which has since come into such general use, and a license for the manufacture of which was, some years ago, sold for a considerable sum of money by a second inventor, was claimed in the above-named Patent.

About the year 1846—after the death of Mr. Hugh Hornby Birley, who with the utmost liberality had provided the means for the carrying out of these inventions—Mr. Bodmer went to London, where his time was chiefly occupied in devising further improvements in the construction of machine tools, locomotive and other steam-engines, and artillery. He left London in 1848 for Vienna, where, in the year following, he was in some respects a highly interested, but rather exposed spectator, from the top of the house in which he had taken up his quarters, of the operations of the Austrian troops against the insurgent citizens. The Soemmering railway was about that time being constructed, and Mr. Bodmer, for a considerable period, made it his especial study to design locomotive machinery, adapted for conveying heavy loads at moderate speeds up and down steep inclines, with safety and economy. After his plans had been sufficiently matured, he put himself in communication with the Directors, but was not successful in inducing the Directors to sanction the adoption of these plans. Mr. Bodmer, subsequently, for a considerable period devoted much of his time to the improvement of the process of the manufacture of beet-root sugar, and gradually designed a novel system of machinery. He was also actively engaged, at times, in working out a new system of Ordnance projectiles, and was in treaty both with the Austrian and the Russian Governments for its adoption. He likewise submitted some of his improvements, as applied to guns of ordinary construction, and an apparatus for bouching cannon in the field, to the Committee appointed to examine and report upon such matters in England, in 1857.

After a few years' residence in Vienna, Mr. Bodmer settled for a time at Lanzendorf, a village situated at a distance of a few miles from Vienna, on the Vienna-Raab railway, where a friend of his was the proprietor of a manufactory of railway wheels, axles, and other objects connected with railway rolling stock, as well as brass boiler

tubes. Mr. Bodmer here made further improvements in steam-engines, boilers, and fire-grates, and also invented an improved safety-valve for steam-boilers; an apparatus for preventing incrustations in steam-boilers; an apparatus and pump for maintaining at all times the same water level in steam-boilers; an improved blow-off cock, an improved water-gauge, two improved governors for steam-engines, an improved water-meter, an improved gas-meter, and a variety of other things. A steam-engine upon Mr. Bodmer's compensating principle, but in which there was only one piston, the cylinder doing duty as the second piston, and both the cylinder and the piston being connected with the same crank,—was constructed, worked, and experimented upon, in connection with a boiler and fire-grate of the improved kind.

About the year 1860, Mr. Bodmer returned to his native town of Zurich, and took up his residence with his son-in-law, Mr. Frederick Reishauer. He was there at first, and for a considerable time, engaged in perfecting his system of breech-loading cannon and projectiles, as also a breech-loading rifle. A cannon on a small scale, and a rifle of the kind alluded to were actually made; and experiments were tried which showed that, although the projectile of the cannon left much to be desired, the mode of locking the breech answered its purpose very well, being free from the serious objections which generally attach to this part of a breech-loading cannon. Subsequently, and amongst a variety of other things, Mr. Bodmer still further improved his system of screwing-stocks, taps, and dies, and the machinery for producing the same.

When young, Mr. Bodmer's activity and endurance knew scarcely any limits; and even in later years he was in the habit of beginning his day's work at five o'clock in the morning; and in fact continued to do so up to within a few months of his death, being engaged in drawing or writing all day, and sometimes far into the night. Mr. Bodmer was elected a Member of The Institution of Civil Engineers on the 15th of February, 1835. He died of a dropsical complaint on the 29th of May, 1864, in the 79th year of his age.

Schedule of Inventions contained in Mr. J. G. Bodmer's several Patents.

No. 6,616, of 1834.

1. Double Piston on Compensating principle, shown as applied to Locomotive Steam Engines.—Apparatus for counteracting the pressure of steam upon the Slide Valve by means of pistons.—Double crankshaft Bearings and compensating Springs.—Segment Guides for Bearings of crankshaft.—Convex spherically-shaped Axle-bearings.—Three modifications of expanding metallic Packing-rings for Pistons.—Self-acting Lubricating Apparatus.—Hollow Piston-rod.

- Mechanism for increasing speed of Driving-wheel independently of that of Engine.
2. Safety Valves. — Draft-Regulating Apparatus. — Mode of producing Draft when the Engine is not running. — Feed-water Heating Apparatus in Smoke-box. — Slanting Fire-grate. — Three modifications of Boilers.

No. 6,617, of 1834.

1. Revolving Drum Fire-grate.
2. Travelling or Propelling Grate, with Fire-bars in Sets.
3. Chain-Grate.
4. Vibrating or Rocking Grate.
5. Application of Propelling Grate to Puddling Furnaces and Brewers' Coppers.
6. Application of Propelling Grate to Hot-air Stoves and Singeing Stoves. — Triple Boiler. — Boiler fitted with Tubes and Chambers placed over Grate and Fire-bars.

No. 6,841, of 1835.

1. Feeding Plate, applied to Willow Machine and Carding Engine.
2. Two modifications of Self-acting Topcard Stripping or Cleaning Apparatus.
3. Arrangement for stopping and starting the Feeding and Doffing Apparatus of a row of Carding Engines, without suspending the operation of the Main Drum. — Mode of conducting Slivers through Spouts and between Press Rollers to Lap Machine.
4. Lapping Machine for Drawing Frame.
5. Position for Lapping Machine of Stubbing Frame, at right angles, or transversely to the Machine. — Twisting Tubes, with reciprocating motion for giving tenacity to the fibres before winding upon bobbins. — Weighted Pressing Rollers in connection with the above. — Improved mode of changing the Bobbins of Lapping Machines. — Various mechanism for imparting a reciprocating motion to the Twisting Tubes.
6. Arrangement of the Unlapping or Unwinding Rollers, as applied to the Feeding of Drawing, Slubbing, and Roving Frames.
7. Application of a system of Drawing Rollers to the Lapping Machine of Carding Engines, instead of Drawing Boxes applied to each Carding Engine.
8. Application of the above system of Drawing Rollers to the Lapping Machines of Drawing Frames.
9. Conducting the Slivers in separate compartments to the Drawing Rollers, by means of several Belts. — Mechanism for traversing and lapping Slivers upon a Bobbin.
10. Apparatus for producing Bobbins, with conical ends, and twisting the rovings.
11. Method of unlapping the Bobbins for feeding Mules and Throstles by means of Belts.

No. 7,388, of 1837.

1. Novel construction and peculiar arrangement of certain parts of the ordinary Throstle, for the purpose of effecting the winding of the yarn upon the bare spindle, in the form of Pincops.
2. Flyer or Guide, and Container, or Box connected with the above: the Flyer or Guide being independent of the Spindle, and acting by virtue of its centrifugal force, when linked to the thread.
3. Apparatus for sizing and preparing yarn in its passage from the rollers to the spindle.

4. Application of two rows of spindles in one Mule carriage, and thereby effecting the 'putting up,' or 'winding on' of the yarn upon one row of spindles, at the same time as the 'stretch' or spinning process is performed upon the other row.

No. 7,837, of 1838.

1. Two modifications of Apparatus for stripping Topcards.
2. Apparatus for stripping or cleaning Main Drum.
3. Self-acting Apparatus for grinding Topcards.
4. Various modifications of Feeding Knife.
5. Lapping Machine for winding a single Sliver or Band on to one Bobbin by means of a right and left-hand Screw-Scroll.
6. Lapping Machine for changing Bobbins expeditiously, by means of a handle and gearing.
7. Machine for winding the Sliver of a Carding Engine layer upon layer, in the shape of a Coil.
8. Coil Machine for the Band of a Drawing Frame.
9. Coil Machine with Twisting motion, for Roving Frames.
10. Two modifications of Apparatus for producing a reciprocating Twisting motion.
11. Independent Spinning Machine.—Application of Differential cones to produce the various motions of the carriage, &c.

No. 8,070, of 1839.

1. Wheel-cutting Engine, for cutting external and internal Spurwheels, Racks, and Bevel-Wheels of Wood and Iron—with adjustable Table.
2. Segmental Cutters.
3. Pentagraph, adapted for shaping Cutters for Spur and Worm-wheels, and for other purposes.
4. Machine for grinding spherical Lenses.
5. Machine for equalizing and polishing large and small feet or cylindrical surfaces, by means of copper discs mounted on slides, and revolving at great velocities.
6. Loose Headstock for Lathes.—Spindle bearing throughout its length.
7. Guiding and adjustable Boring Tool.
8. Expanding Mandril.
9. Planing Machine.—Double Tool Slide, with self-acting apparatus to move out of cut, and moveable vertically, horizontally and about the centre.
10. Planing Machine with moveable bed outside, and independent of Tool Slides, for vertical and horizontal cut.—Tool Slides as above.
11. Hand-Planing Machine, worked by contact pulleys.
12. Planing Machine with adjusting Table, moving on Pivot, for cutting polygonal articles.
13. Nut-cutting Machine, for cutting two sides of a row of Nuts, placed on a mandril, simultaneously; fitted with dividing apparatus.
14. Circular Planing Machine, for turning, planing, and boring large wheels, or other parts of machinery.
15. Differential Double Screw Slide-lathe, for turning Cones, rounding the surfaces of pulleys, turning Ball-sockets, and Balls, and cutting Screws of any desired pitch.—Apparatus for moving Slide separately from Screw.—Apparatus for moving Tool in and out of cut quickly.
16. Apparatus for cutting Nuts on Lathe.—Nut-cutting Bar, for cutting Nuts of large size.
17. Drilling Machine with differential Feeding Apparatus.

18. Slotting Machine or Key-grooving Machine, fitted with Apparatus for taking Tool out of cut in the upstroke.—Tool Slide adjustable for cutting at angles.
19. Tapping and Screwing Machine.
20. Novel arrangement for securing Cutters in Connecting-rod ends and Straps, by means of a set-screw.
21. Rolling Mill for rolling Tires for Railway and other Wheels to their finished shape and size; so as to dispense with any further operations.
22. Rolling Mill for rolling Hoops for Boilers.—Various modes of jointing such Hoops with flush joints.

No. 8,912, of 1841.

1. Lathe for turning Crank Axles, fitted with two-face plates driven simultaneously from a horizontal shaft, by means of pinions, gearing into the toothed circumferences of the face-plates: the face-plates being fitted with adjustable bearings, which can be set to any desired distance from the centre, according to a scale marked thereon.
2. Universal Joint; in which the ball and socket, and the swivel principle are combined in such a manner as to increase the strength of the mechanism, without prejudice to its efficiency.
3. Connecting-rod Head.—Connecting-rod End turned cylindrically, and bored out spherically for the brasses.—Strap bored out internally and turned externally.
4. Tool for boring out Connecting-rod Straps.
5. Tool for turning Spheres.
6. Screwing-Stock with moveable Cutting Die.
7. Tap for cutting internal Screws; thread 'backed off' both at top and bottom: called Convolute Tap.
8. Adjustable Chasing Tool and Holder.
9. Self-acting Tap-cutting Lathe for forming Convolute Taps.
10. Apparatus for regulating or correcting Screws, by means of a Screw working in wood, and regulated by gearing.
11. Large Slotting Machine.—Tool actuated by a Screw in combination with Rack and Pinion, and brought into and out of cut by inclined planes.—Tool reversible.—Machine also adapted for cutting Grooves or Slots, like an ordinary Planing Machine.
12. Double Drilling Machine for large and small Holes, fitted with differential gearing to effect the feed, which remains uniform, however the metal under operation may vary as to its hardness or porosity.
13. Centre-Chucks for Lathes, in which the Jaws are moved simultaneously by means of a Central Wheel fixed to the Spindle of the Headstock.
14. Planing Machine worked by a Crank-motion.—Various modifications of Starting and Stopping Apparatus.
15. Planing Machine, in which the Table is actuated by means of a Worm gearing into a Rack, which is a segment of a Nut.
16. Wheel and Screw Press for forcing Mandrils into Wheels.—Also to be used as a Drifting and Trenching Machine. This machine is fitted with a short-stroke Eccentric, and the combination of mechanism is such that the Mandril or Punch is constantly in contact with the object to be operated upon.

No. 8,981, of 1841.

1. Fan-propeller, in connection with Compensating or Double Piston Steam Engine.
2. Expansion Valves, regulated by right and left Screw.

3. Pillar Steam Engine, with stationary Piston and moveable Cylinder.
4. Compensating or Double Piston Steam Engine applied to Paddle-wheel Propeller.—Paddle-wheel so constructed that the dip of the Floats can be adjusted.—Stationary shaft Paddle-wheels driven by Pinion gearing into segments.
5. Mode of jointing the Plates of Iron Ships.
6. Inverted Cylinder Stationary Compensating or Double Piston Steam Engines.
7. Locomotive Compensating or Double Piston Steam Engine.—Framing formed of timber, in layers.—Connecting-rod brasses turned spherically.—Spherical Axle-bearings.—Hand-gear.—Broad Railway-wheel Tire, in combination with flat Rail, bedded on cylindrico-concave longitudinal Sleepers, with a soft or elastic substance between Rail and Sleeper.—Oiling Apparatus.

No. 9,279, of 1842.

1. Blowing Machine for producing narrow Laps, in connection with Lapping Machine patented in 1838.
2. Self-acting Doffer Knife to Lapping Machine.
3. Improvements in self-acting Topcard Stripping or Cleaning Apparatus.
4. Main Drum Stripping Apparatus.
5. System of feeding Carding Engines with narrow Laps.
6. Lapping Machine for winding one or more Bands or Rovings on a Lap, with use of Doffing Knife.
7. Coil Frame, with Twisting Apparatus.
8. Double Coil Frame.
9. Improvements in Apparatus for forming the Cops in 'Throstle,' patented in 1837.—Also improved Flyer and Container.

No. 9,547, of 1842.

1. Construction of Tire Rolling Mill.
2. Squeezing Rollers for Puddling Furnaces.
3. Modified form of Tire Rolling Mill, with two Working Rollers.
4. Rolling Mill for producing Tires from Bars, not having originally the shape of Tires, or even from flat bars.—Internal Rollers governed by right and left-hand screw and weight, for keeping the Tyre steady under operation.—Supporting Rollers, to diminish friction and preserve the Table from wear and tear.
5. Machine for forcing Tires on Wheels.
6. Shearing Machine, adapted for preparing Plates to be subsequently rolled into Pulleys and other Hoops.
7. Tire-welding Machine.

No. 9,702, of 1843.

1. Improvements in Compensating or Double Piston Locomotive Steam Engines.—Expansion Gear, and mode of regulating the same.—Hand-Gear, Pistons, and Axle-boxes.
2. Tender.—Framing.—Break acting simultaneously upon the Rails and Wheels.
3. Tire Rolling Mill.—Gauging Apparatus to ascertain size of Wheel Tire.
4. Welding Furnace for Tires.
5. Peculiar construction of Compensating Crank.—Combination of Crank with Shaft, by means of Universal Joint and spherical Bearings.
6. Steam-engine Governor acting upon Expansion Valve.
7. Wheel with bent Spokes.

8. Mercurial Steam-regulating Gauge, to act in connection with the Safety Valve, and to let the surplus steam flow off to any place where it may be required, or to cause it to act against the Pistons of the Engine, so as to regulate its velocity more quickly.
9. Compound Compensating or Double Piston Steam Engine in connection with Paddle-wheel Propellers.
10. Wheel-break or Starting and Stopping Apparatus, as applied to Rolling Mills; and in combination with Paddle-wheel Propellers, to stop and start the latter instantaneously, though without any concussion and jerking, and without stopping the Engine.
11. Life-boat, with Fan-propeller fitted to it.—Various modes of jointing the Plates of Iron Vessels.
12. The Compensating or Double Piston principle applied to Pumping and Winding Engines.
13. Couplings of Pumprods and Shafts.
14. Modification of Starting and Stopping Apparatus, as applied to Winding Gear.

No. 9,899, of 1843.

1. Screw Fire-grate, with rocking motions of Bars.
2. Metallic Packing for Piston-rods, Pump-rods, and Cocks and Taps.
3. Lathe for cutting Pattern of 'drunken' Screw, to produce Rocking motion of Firebars.
4. Mode of applying Screw Fire-grate to Cementation Furnaces.—Mode of treating the Iron previously to packing it in the Boxes.
5. Continuous Cementation Furnace with spiral Flues.
6. Puddling Furnace, with Double Hearth: namely, an upper Hearth to smelt the Iron, and a lower one to form Balls.—Application of Screw Fire-grate to the same.
7. Smelting (Air) Furnace, in which the air is drawn down upon the hearth, from above, by means of a Fan.
8. Application of Screw Fire-grate to Air-heating Apparatus.
9. Band Saw, and mode of manufacturing the same.

No. 10,243, of 1844.

1. Outside Cylinder Compensating or Double Piston Tank Engine.—Brass Fire-box with Partitions.—Air-pump for forcing Atmospheric air into Boiler.—Fire-bars with rocking motion.—Brass Leading and Driving Wheels.—Elastic Connecting or Coupling Rods.—Expansion Apparatus.—Use of four Cylinders, of which the two internal ones are in connection with Crank-shaft, and the external ones in connection with Crank-pins.—Hollow Brass Piston-rod, in connection, or rather of one piece with the Slide-block and Pin.
2. Expansion Gear.
3. Mechanism for working Link-motion.
4. Tender.—Mounting Feed-pumps on Tender, and working the same from the running Wheels instead of fixing them to Engine as usual.—Improved Drag-links, with spherical or Ball-sockets, which are at the same time the tubes by which the water is conveyed from the Pumps to the Boiler.
5. Brass Crank-shaft, with eccentrics cast of one piece.
6. Four Modifications of Expansion Gear.
7. Valve for Atmospheric Railway.
8. Pair of 300 H.P. Horizontal Compensating or Double Piston Bevil-gear Screw Steam Engines.—Air-pump working at reduced speed.—Pipe, Cylinder-cover, and Cylinder Heating Apparatus.—Yielding Cylinder Top and Bottom, to prevent accidents through accu-

- mulation of Water.—Application of Spherical Bearings to Screw-shaft.
9. Propeller Shaft Stuffing-box and Gearing.—Peculiar method of coupling and unshipping the Propeller-blades, which operations can be easily effected when under way.—Peculiar method of coupling the Propeller-shaft with the Engine.
 10. 300 H.P. Stationary Inverted Cylinder Compensating or Double Piston Steam Engine, with external Crank.—Reduced speed Air-pump.
 11. Modification of Variable Expansion Gear and Slide Valve.
 12. High-pressure, Non-condensing Compensating or Double Piston Steam Engine, with Governor acting upon a Throttle Valve in the Exhaust Steam-pipe.
 13. Expansion Valve Governor.
 14. Steam Boiler with 'Bouloirs,' adapted for Screw Fire-grate.
 15. Tubular Boiler.
 16. 300 H.P. Horizontal, Compensating, or Double Piston Steam Engine, connected with a pair of Vertical Fan-propellers.—Peculiar construction of Propeller and Feed-box, and Regulating Apparatus.
 17. Application of Friction Break or Starting Apparatus to Crank-shafts of Marine engines, for connecting or disengaging Paddle-wheel or Screw-propeller.
 18. Application of Friction Break or Starting Apparatus to the end of a Shaft, for connecting the same with, or disengaging it from another Shaft, through the medium of a Universal Joint or Coupling.
 19. Spherical Bearings, especially adapted for heavy Shafts, and where the Pedestals cannot be fixed to a solid foundation; as, for instance, for Shafts of Screw-propellers.
 20. Application of Friction-break, or Starting Apparatus, to the Fly-wheel of a Rolling Mill, or other heavy machinery requiring to be suddenly started or stopped, and where the resistance to be overcome by the Motor is liable to be suddenly increased.—Also application of the same Apparatus for reversing the motion of the Rolls of a Rolling Mill.
 21. Further modification of the construction of the Friction-break or Starting Apparatus.
 22. High-pressure Tubular Marine Engine Boiler, fitted with Travelling Grate.—Inside Fire-box with corrugated Roof.—Water-bridge.—Fan blast with regulating Flues, for the purpose of giving any direction to the current of Air.
 23. Balance-rudder, and mode of unshipping and replacing the same.—Metallic Tube to which the wings of the Rudder are attached.
 24. Adaptation of the Compensating principle to Pendulum or Vibrating Steam Engines.
 25. Inclined Cylinder Compensating Trunk Engine.—Air-pump for high velocities.

MR. RHYS WILLIAM JONES, the eldest son of the late Mr. Rees Jones, of Penybailly House, Loughor, Glamorganshire, was born in Swansea in the year 1804. After receiving a liberal education, he became actively engaged under his father, who was a Mineral Engineer well known in South Wales, and likewise served a pupilage under the late Mr. Rennie. At an early period of his career he was employed under Mr. H. R. Palmer, then acting for Mr. Telford on the survey for the improvement of the turnpike