form of compound engine which, when the efforts of the two pistons are equal, realises the greatest economy in shaft friction possible with two cylinders only. It is deficient in the power of turning the centre, so that in steam vessels it is advisable to use such engines in pairs.

Case VII.—Two cranks, between the shaft bearings, opposite in direction; four pistons, each crank driven by two piston-rods at right angles to each other. The solution of this case is obtained by combining those of case III., and of the third example of case VI., that is to say, comparative shaft friction $= \sqrt{\frac{2}{2}} - \frac{c}{b}$. This is nearly the arrangement in some pairs of compound marine engines made by Messrs. Randolph, Elder, and Co. The pairs of piston-rods are not in every case exactly at right angles; to allow for this let the angle which they make with each other be $n^1 \pi$, being the fraction n^1 of a half revolution; then for the preceding expression substitute the following:

$$\frac{c}{2b}\left\{ n^1 \sqrt{(2 - 2\cos. n^1 \pi)} + (1 - n^1)\sqrt{(2 + 2\cos. n^1 \pi)} \right\}$$

The result, when $n^1 \pi$ is an oblique angle, is greater than when it is a right angle, but the difference for small obliquities is unimportant in practice.

Case VIII.—Three cranks, making equal angles of 120 deg.; two shaft bearings only with sensible pressure at the distance apart b; the middle crank midway between the bearings; the other two at equal distances $\pm c$ from it, three pistons, with parallel rods. The aggregate of the pressures at the crank bearings being $3 \cdot P$, their resultant force is at all times $= P$. The resultant moment is nothing when the two outer cranks are at the same side of the shaft, and $2 P c$ when they are at contrary sides, the latter being the case during two-thirds of each half revolution. The pressure at a given bearing has in the three successive thirds of each half revolution the three values, $\frac{1}{2} P - P\frac{c}{b}$; $\frac{1}{2} P$; and $\frac{1}{2} P + P\frac{c}{b}$. The aggregate of these pressures has one or other of the following values, according as $\frac{c}{b}$ is less or greater than $\frac{1}{2}$. If $\frac{c}{b}$ is less than $\frac{1}{2}$, P. If $\frac{c}{b}$ is greater than $\frac{1}{3}$, $2 P \frac{c}{b}$ for two-thirds of each half revolution, and P for the remaining third. Hence we have for the comparative shaft friction:

$$\text{If } \frac{c}{b} \text{ is less than } \tfrac{1}{2};\ \tfrac{1}{3} = {\cdot}333 \text{ nearly.}$$

$$\text{If } \frac{c}{b} \text{ is greater than one-half } \frac{4\frac{c}{b} + 1}{9}$$

This arrangement of cranks occurs in the three-cylindered engines of Messrs. Maudslay; but as there are intermediate bearings between the cranks the calculated result will not be realised unless the pressures at these bearings are insensible.

Case IX.—Three cranks between two shaft bearings; the two outer cranks opposite in direction to the middle crank: the three piston-rods parallel; the efforts of the two outer pistons each equal to one-half of the efforts of the middle piston. Here there is a balance of efforts at all times, the resultant force and the resultant moment being each sensibly equal to nothing. The shaft friction is simply that due to the weight of the shaft. This arrangement realises the greatest possible economy of power in the friction of the shaft journals. It was the invention of the late John Elder, who used it in compound expansive engines with the high-pressure cylinder in the middle, and a pair of low-pressure cylinders, one at each side. In order to turn the centre, and give uniformity of action, he combined those three-cylinder engines in pairs, with piston-rods at right angles, acting on one set of three cranks, so that there were six cylinders in all. Such was the construction of the engines designed by Elder for H.M.S. Constance; and upon trial they showed an economy of power, over and above that due to expansion, which can be accounted for only by the smallness of the journal friction.

8. *Remarks.*—It appears from the preceding examples that various degrees of economy in the friction of the engine shaft journals may be attained by means of suitable forms of engine; the higher degrees of economy requiring more numerous cylinders, and consequently greater cost, and the highest possible degree, three cylinders for a single engine, and six for a pair of engines. It may not be always advisable to increase the number of cylinders for the sole purpose of diminishing friction; but when, for other objects, such as high rates of expansion, many cylinders are used, it is very important to know how to arrange them so that they may, by the balance of efforts of the pistons, realise the greatest economy of friction consistent with their number.

W. J. M. R.

TWIN-SCREW ENGINES OF THE STEAMSHIP MAGLORIA.

We publish this week a two-page engraving illustrative of an arrangement of twin screw engines manufactured by the North-Eastern Marine Engineering Company (Limited), at their Sunderland Engine Works, from the designs of Mr. Allan. The cylinders are 24in. diameter, having a stroke of 2ft. The engines are fitted with variable expansion valves; the pressure of steam used is 40 lb. To the piston-rod of each cylinder is attached a crosshead, which works respectively the air, circulating, feed, and bilge pumps. The chambers of the air and circulating pumps are cast on to the condenser sides; on the outer or wing frames are the feed and bilge pump chambers and valve chests. The arrangements for reversing, &c., are in the simplest possible manner; the reversing wheels, expansion handle—which actuates the four valves at once—throttle valve, &c., are under the immediate control of the engineer. The condenser is so constructed that all parts are easily accessible. It will be seen that the design of these engines is in many respects like that of the compound engine constructed by the same firm, and illustrated in our impression for June 9th, 1871. The workmanship is very good, and the engines have given much satisfaction.

The reconstruction of the Vendome Column is entrusted to M. Vermont, architect, who held for several years the post of conservator of that monument.

MURCHISON AND BABBAGE.

The scythe of time has swept ruthlessly over the octogenarians of British science. Within the last few months we lost Herschell and Burgoyne, and now Murchison and Babbage—both whose names, though in different spheres, have been for the last half century almost familiar words amongst us—are gone also. Charles Babbage died on the 18th of October inst., at his house in Dorset-street, London, aged nearly eighty years, having been born, according to his own statement, on St. Stephen's Day, 1792; and Sir Roderick I. Murchison's decease took place on the 22nd of October, at Belgrave-square, at nearly the same age, his birth having taken place at his father's house in Ross-shire, in February, 1792. No two men, both possessing real credentials to eminence and fame, present more singular, and in some respects instructive, characteristics in their careers, as contrasted and as paralleled with each other.

Babbage, born of a family of the *bourgeois* class, though sufficiently well to do to have sent him to Cambridge, was educated in the regular course of academic studies, and reached the highest points of intellectual attainment accessible but to few among men. Murchison, born of an ancient Highland stock, received only such education as the Grammar School of Durham and the great Marlow military school afforded sixty years ago, and began his real life in a regiment of Irish militia, without special scientific schooling, and dependent for his acquirements on his own bent and open-eyed observation in after life. Yet Murchison lived to achieve for himself nobility and a far from baseless reputation as a geologist, to have been the honoured guest and occasional oracle of emperors, and to have been courted in all society and everywhere in Europe. Babbage, honoured, and but justly, for his lofty and abstract attainments, for his brilliant conceptions, his lucid and often poetic expression of thought, his originality of view, often for his wit, amongst the few to whom the fame of the Academy—to employ Bacon's words—is more valued than that of the market place, was known to the public through little more than a vague and ignorant wonder at the name of one who was reputed to have made machinery think or do the work of thought, and never rose to the position in society that his intellectual gifts demanded as a right. This position, notwithstanding anything on his own part to the contrary, would have been higher and more splendid were genuine scientific eminence and its claims better understood and recognised by the Sovereign and so-called aristocracy of these realms.

What, however, were the real causes of this strange diversity of career in the two men—Babbage, with these lofty gifts of pure intellect, that amazing richness in acquirement and facts, was devoid of sound judgment in almost every affair of life without mental perspective, so to say—often wholly deficient in the larger sense and use of tact, sometimes severe in his condemnations, and, even when enchanting by the brilliancy of his conversation, chilling by a certain sombreness of temperament that repelled many friends, and by a neglect of congruity (it may be of the prejudicing of others) that sometimes shocked those nearest and most full of appreciation for his powers. Though mixing freely and frequently with general society in his earlier life, and with that of the learned even to the end, he may be said to have lived and died a solitary man.

Murchison, on the other hand, was the very personification of courtliness, and to all men urbane and gentle, and in larger or public affairs was pre-eminent in tact. Nor was he, with all this, a mere hollow Chesterfield. He was a man of genuine *bonhommie*, and of real good nature—one to whom it was a real pleasure to help every friend in his career, as well as to aid the advance of scientific merit. With mental powers greatly below those of Babbage, and by nature taking rather the observational than the inductive or mathematical form, he was far his superior in the possession of a sound faculty of judgment and a clear mental vision that saw its object always in due proportion and distance, recognised the limits of the possible, and gained the support of other men, though *they* might have seen no more than that which Murchison adopted as his own, had for that reason some *à priori* recommendation for its soundness or truth. With these qualifications, and adopting the more popular and flowery path of geology and geography, Murchison thus gradually became recognised as amongst the foremost man of these branches of knowledge, and as surely became the best known of men with a scientific reputation, amongst the world of fashion, and in the reunions of the great, to whom his gentle descent, his early military life, and his dignified manner and fine presence, were additional, and perhaps chief, passports. The contrast, if duly expanded with such illustrations from the lives of the two men as we cannot find space for in these pages, would be highly instructive to everyone seeking to discover a solution of that problem so often proposed, so often so meanly discussed—how to rise in life.

Charles Babbage has left after him above eighty memoirs, papers, or volumes. Of the former some of the most important, intellectually considered, are those "On the Calculus of Functions," chiefly in the "Philosophical Transactions," and some mathematical papers in periodical journals. He is popularly best known as the so-called inventor of the calculating machine, and as to his works, by "The Ninth Bridgwater series." Had we space at command it were easy to show that the calculating machine owed its abortiveness mainly to Mr. Babbage's own incapability of acting with other men, and to that want of mental perspective which induced him to waste his own time and energy in attemping to acquire the skill of a working mechanic, which he might have sufficiently commanded in the person of any one of a thousand clockmakers in Europe. What but failure could attend the man who, having been given national aid to complete a given machine—the Difference engine—goes a certain length with it, and then suddenly proposes to abandon it because he had invented the Analytical engine, one of enormously greater power?

Sir Robert Peel judged soundly when he concluded that in the hands of a man so acting, however intellectually endowed, no machine was ever likely to become an actuality. This is not the whole story, we admit, and we regret that on this occasion at least we cannot, perhaps ought not, to discuss it more fully; but it is the main thread. Babbage would have achieved, and earned in doing so an abiding fame, what Pascal and others only dimly saw, what Scheutz and others have since without aid in part effected—had his noble brain been united with more common sense notions of managing mankind.

On Sir Roderick Murchison's labours as a geologist it is less still within our compass to dilate. He has published a large number of geological and geographical papers, scattered through various Transactions and periodicals; but his two great works are "The Silurian System," wherein he was the first to give a stratigraphical position to those enormous and ancient slaty rocks, such as those of North Wales—the ancient Siluria—before confounded with many other formations under the barbarous Wernerian name of *Grauwacke*, and his geological survey of parts of Russia, in concert with M. de Vernieul and Count Keyserling. Much popular attention was excited at a former period also by his so-called prediction of the occurrence of gold in Australia. Sir Roderick was for several years the urging force and chief cause of the brilliant successes of the Royal Geographical Society; but as we have said elsewhere in these columns, it is matter of deep regret that the energies which he then made so successful were not shared with, if not devoted to, the like expansion of the School of Mines in Jermyn-street, over which, along with being director of the Geological Survey, he for several years presided, but the real public value and scope of which institution he does not appear ever to have understood. It would be an error to say that the works of either of these celebrated men will be forgotten, or that the fame of either will be merely ephemeral; but if that of Murchison has been in life the more brilliant and fortunate, we are inclined to think that, whatever may have been his failings, the fame of Babbage will be the more enduring.

SIEGE OPERATIONS AT CHATHAM.

A comprehensive programme of experiments was carried out at Chatham on Tuesday last (October 24th), in presence of H.R.H Commanding in Chief, under the orders of Colonel Gallwey, R.E., Commandant of the School of Military Engineering. The northern portion of the permanent fortifications, and of the ground devoted to field works, was entirely taken up by the operations of the day, the experimental undertakings of the summer being woven, as far as was practicable, into a consistent plan of attack.

Opposite to the right demi-bastion of St. Mary's, the Royal Engineers have, during the summer, conducted an attack by mines, in the face of an independent defence by countermines, until there were established two mines, each containing 1000 lb. of powder, the firing of which was reserved for this day.

A double sap had been pushed up to the crest of the glacis of the Redan connecting St. Mary's left demi-bastion with the Gillingham face of the works; and a less complete double sap had been pushed towards Prince Edward's bastion. The lines of trenches in rear of these saps and mines consisted of four parallels, with demi-parallels, elevated and sunken batteries, and certain characteristic specimens of gun-pits used by the Prussians during the recent war. The siege operations of the day were as follows:—The mines were sprung, and a lodgment effected—supposed to take place late in the evening. Some hours afterwards—supposed to be at dawn—the garrison sprang two counter mines and blew in the lodgment, following up the effort by a brisk sortie, in which they succeeded in turning the besiegers' most advanced works, while a sudden attack of cavalry coming out upon one flank assisted to drive back the guard of trenches temporarily; though eventually the besiegers, strongly reinforced, compelled the garrison to fall back. The besiegers then assaulted by escalade, effecting an entrance by the Gillingham face, but repulsed for a time at Prince Henry's bastion; eventually, however, carrying the entire works.

On the whole, the programme was carried out with remarkable success, and but few blunders even in detail were noticed; the most obvious one, perhaps, was committed by a detachment of the 3rd Dragoon Guards, who, failing to pounce on the flank of the Rifle Brigade at the Gillingham face, until the latter had fallen back behind a parapet, charged along their front within thirty yards of the muzzles of a long line of Sniders firing in a manner that must have annihilated them. The following independent experiments were conducted:—A stockade was demolished in one place by 100 lb. of powder, and at another by 40 lb. of gun cotton, showing the respective effects of the two methods. Six submarine mines, forming a line across the Medway, were fired in immediate succession from the instruction vessel Volta. Her Majesty's paddle-wheel steamer Bustler (representing a friendly vessel) steamed over a submarine mine, hauling a raft (representing a vessel in pursuit); the latter on arriving over the mine was blown up by a charge of 50 lb. of cotton. These submarine experiments were, as far as they went, satisfactory; the successive firing of the six mines in line was well effected, but it is to be noticed that any contingency that might interfere would be more likely to arise when the full charge of 500 lb. to each mine was used than the reduced charge of 50 lb.; further, the volta was in close proximity to the work. To test to any great extent the system of firing mines by observation a more distant station might be selected with advantage. This subject is one at present of special interest to the country; an extensive system of defence of harbours by torpedoes has been approved of, but the store of gun cotton for the same has been submerged, and much of it is known to be in an unsafe condition, as noticed in our article on the Stowmarket explosion of Sept. 15th last. At the bathing pond experiments were carried out to exhibit the relative merits of Blanshard's pontoons and those of the new boat pattern, recommended by the Pontoon Committee; the latter are made of a remarkable description of colonial pine, termed "cowrie pine;" very light, close in grain, free from knots, and attaining a great length; it is not considered to stand well when exposed to the air, but in these boat pontoons it is covered with canvas and marine glue, or Clarkson's material. The chief novelty in this part of the work is the employment of "steam sappers," constructed by Aveling and Porter, of Rochester. These are light, strong, traction engines, capable of driving machinery, one of them, of 6-horse power nominal, being at present engaged in driving the following machinery:—Circular saw, general joiner, iron lathe, forge bellows, and grindstone. The other, rather a lighter one, weight, 94 cwt., recently noticed at length in our pages, on this occasion moved over the new pontoon bridge, and afterwards hauled heavy siege material across it. The steam sappers are capable of moving in very heavy ground indeed, for which work paddles are fixed on the tires of their wheels. They can draw about 15 tons up an incline of 1 in 12, the wheels being furnished with pegs, which are inserted in their tires, to give a firm hold in the ground. They would be most valuable for almost any description of heavy work on active service that was not conducted under fire.

The American tube well, a variety of lever and truss bridges, field observatory, and field telegraphs, and above all the Swiss pile-driving apparatus, which we shall describe in an early impression, completed the number of the objects of interest in the way of military engineering.

Steam Ploughing in Gloucester.—We learn from the *Gloucester Chronicle* that Mr. Hayes, of Stoney Stratford, is achieving considerable success in Gloucestershire with his patent windlass tackle, already noticed favourably in our columns.

Locomotives in the Metropolis.—At the meeting of the Metropolitan Board of Works on Friday last the following order was made as to the hours during which, and as to the speed at which, locomotives are to pass through the places subject to the jurisdiction of the said board:—"No locomotive propelled by steam, or any other than animal power (except a steam fire-engine actually going to or returning from a fire), shall be driven or conducted, or be allowed to pass through any street or place within the limits of the jurisdiction of the said board, between the hours of six o'clock in the morning and ten o'clock in the afternoon of any day, and, with the exception of these hours, locomotives may pass along the streets and places aforesaid. And the board orders that the speed at which such locomotives shall be driven or pass through any street or place within the limits of the jurisdiction of the board shall not exceed two miles an hour. This order does not extend to the city of London or the liberties thereof, and it does not in any way apply to locomotives called steam road rollers, or however they may be named, which are used for making or repairing roads."