J. Ross.

The James Watt, Steam Packet, propelling against

A STORM,

On the Night of the Twentythird of November, 1824.

A

TREATISE

ON

NAVIGATION BY STEAM;

COMPRISING A

HISTORY OF THE STEAM ENGINE,

AND AN ESSAY TOWARDS A SYSTEM OF

THE NAVAL TACTICS PECULIAR TO STEAM NAVIGATION,

AS APPLICABLE BOTH TO

COMMERCE AND MARITIME WARFARE;

INCLUDING A COMPARISON OF ITS ADVANTAGES AS RELATED TO OTHER SYSTEMS IN THE CIRCUMSTANCES OF

Speed, Safety and Economy,

BUT MORE PARTICULARLY IN THAT OF

THE NATIONAL DEFENCE.

PATRONIZED BY

HIS ROYAL HIGHNESS THE LORD HIGH ADMIRAL.

ILLUSTRATED WITH PLATES AND ENGRAVINGS.

BY

CAPTAIN JOHN ROSS, K. S. R. N.

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TO HIS ROYAL HIGHNESS

THE LORD HIGH ADMIRAL

OF GREAT BRITAIN,, &c. &c. &c.

SIR,

THE era which placed your Royal Highness at the Helm of the British Navy, being that of the introduction of the Steam Engine into His Majesty's Fleet, I had the honor to lay before your Royal Highness my proposition of publishing a System of the Naval Tactics peculiar to Steam Navigation, the result of much labour and enquiry; urging the necessity of instructing the Officers of the Royal Navy, in the theory of that important part of their profession. Notwithstanding the general prejudice against innovations on a system which has for ages protected the nation, and raised our naval renown to the pinnacle of glory, Your Royal Highness patiently listened to my arguments and suggestions, and, with a laudable desire to afford every facility to improvements, was graciously pleased to sanction my humble undertaking, and to permit me to dedicate the fruits of my labours, to The Lord High Admiral. Impressed with unfeigned gratitude for this mark of condescension, as well as for the honor which has thus been conferred upon me, and with an anxious hope that my endeavours may prove worthy of them, I beg leave to subscribe myself,

Your Royal Highnesses
Most Dutiful and
Most Obedient Servant,
JOHN ROSS,
Captain of the Royal Navy.

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INTRODUCTION.

In the late war which desolated Europe for twenty-three years, events took place which raised the glory and renown of the British Navy so decidedly above all other nations, that it was considered a settled point, and a generally acknowledged fact, that the "Wooden Walls of Old England," were alone a sufficient protection to her shores, from foreign invasion. Her fleets were no sooner laid up dismantled in her harbours, and those officers who had hitherto been actively employed in offensive and defensive warfare, doomed to spend the remainder of their days in contemplation of the past, than their minds were naturally turned towards the various scenes they had witnessed, and in "fighting their battles o'er again," they reviewed the peculiarities of every action, and being naturally led to reason and reflect on the importance of the subject, in the event of a renewal of hostilities, and with a most patriotic and laudable desire to improve the young and aspiring officers, who are expected to maintain the glory, and ensure the future safety of the nation, they felt it a duty incumbent on them to publish those facts and opinions which had been so fully established by talent and experience; thus affording advantages to the rising generation of officers, which would bring them at once to a knowledge of the profession, which, without those, could not have been obtained in years of practice. Among these, I may mention the works of Admiral Pender on "Seamanship," Captain Griffith's "Practical

Hints," and Admiral Ekin's "Naval Battles," &c.; the two former giving a complete system and view of seamanship, and deciding points in the profession which were even doubtful among experienced officers, and often subjects of controversy on which the sailor could not make up his mind during the course of an active life; and the latter, giving an insight into the higher branches of the profession, which would have been invaluable to most of those captains who commanded ships of the line during the war. Had no alteration taken place in naval tactics or warfare, these would have remained standard volumes in the library of every naval officer.

Navigation in general, has however undergone so complete a revolution by the introduction of the steam engine, as to render its theory and practice no longer the same, and, consequently, the able works alluded to, are no longer of that importance which were at first attached to them; the change which has taken place, is however still more applicable to naval warfare, than to commercial or mercantile purposes, and we trust that this fact has not been overlooked by those whose duty it is to watch over and defend our country.

There is, indeed, abundant reason to believe, that it is fully felt, not only by the government itself, but by every naval officer who has bestowed the slightest attention on the subject; while, if it be true, as is generally understood, that our rivals and enemies are turning their attention very particularly to this object, it is the more incumbent on us to see that no time is lost by ourselves, in taking such steps as may insure us that continued superiority at sea on which our very existence depends.

It is for the purpose of hastening the general attention to this most vital subject, that the present work has been undertaken; imperfect as it needs must be, where every thing is entirely new, and we have as yet no experience to guide us. Such as it is, pretending to no more than a bare sketch of what time and practice must hereafter fill up, it will at least serve to call the thoughts and labours of other officers to the same subject, while I may occupy a few pages of introduction on some general remarks on the most leading points connected with a system of offensive and defensive Steam Navigation.

The first remark is, that such a system will require a great numerical increase of officers, in the event of a future war, proportioned to that of the men; whether the object be merely the protection of our commerce, or a national defence against invasion and active offensive warfare. Such officers, must also be educated with the knowledge, not only of Steam Navigation, and of the construction and management of Steam Vessels, but of the very machinery and principles of the engine itself, without which they will rarely be efficient for their duties; much as the adequate management of a ship of this nature depends on an intimate knowledge of its moving power, and highly necessary as it is that they who command should be able to direct and controul every thing. It is indeed plain, that if it is necessary that a good officer should be intimate with every thing that appertains to the construction and guidance of a ship on the present system, so that he may direct every thing and depend on no one, not less is it indispensible that he should equally know every thing which relates to the new force which will thus be placed in his hands.

It is moreover plain to a very slight reflection, that the adoption of this mode of motion, and these new inventions, will produce an entire revolution in the present system of attack and defence, and that an entire new method of tactics must be a necessary consequence; great differences in the management and conduct of vessels, whether separately or in bodies, must follow from substituting the present mechanical powers, utterly independent as they are of the wind, for those which depend solely on that force; and hence, an entire new course of study becomes opened to naval officers, no less indispensible, than it is new. Thus, for example, must the ancient rule of forming the line of battle, be utterly changed;

since the nature and direction of the wind will no longer form the same elements of calculation: and similar changes will become necessary, in the modes of attacking and defending, and even in the usual and simpler cases of chasing, and of other operations between single ships. Some of these will be demonstrated hereafter; but I may also here remark, that another essential variation in the conduct of ships of war, in action, or intending it, will occur in the present system, from the power which is possessed of rendering vessels of this nature partially invulnerable, and of making them shot proof, within at least, certain limits. Thus, for example, it will become possible, for a ship rendered shot-proof, within six hundred yards, or more or less, should it so happen, to approach within that distance of a ship of the line, and, even with one gun, to maintain an action, perhaps to disable and destroy her much more weighty opponent; while the difference in favour of the steam vessel is obvious, because the machine can be secured, both by being fortified and placed beneath the water, so as to keep the hull and all the moving power secure from injury, when the sails and rigging of her antagonist, or her moving powers, are as well as her hull, completely exposed; constituting a difference, the great influence of which can be immediately appreciated.

Another advantage appertaining to steam vessels thus fortified, which is also of immense importance and effect in its general results, as to naval warfare, is this, that a vessel of this nature cannot be boarded by boats; while the general system of attack and defence on boarding at close quarters, must also undergo an entire change, as the least consideration will render apparent. In reality, a steam vessel, fortified in the manner above alluded to, is incapable of being boarded at all, and cannot be taken in this manner; while it is plain also, that this mere fact will lead to considerable changes of plan and conduct in the case of close actions.

Still more, a steam vessel may be rendered a single offensive weapon in herself, on a system similar to that of the ancient warfare of galleys in the time of Rome; and to use familiar language, may be employed in running down its antagonist, by the mere impulse of a fortified stem, accompanied by a superior weight and velocity; while this is a species of attack, which, by being always at command, and being independent of wind, will necessarily lead to manœuvres at once new and complicated; since the object of the assailant will be to attack the broadside, or most vulnerable part of the enemy, reversing entirely, what is now attempted. If I add to this, that vessels of this description may easily engage with red-hot shot, and with other missiles, which the present system does not appreciate, or which are now not deemed convenient, it is further easy to see that there is scarcely a limit to the changes which a system of this nature will introduce into naval warfare, and that consequently, an entire new course of study will be required in training both men and officers to this science.

It is true, however, I fear, that there are many old officers, who as yet oppose the introduction of this system, or doubt of its practicability; and if it be so, it is no great cause of surprise, while it must be also allowed, that there are objections, many of which are more obvious than admissible. Certain it is, that should such a system become general, we must bid farewell to the pride of seeing our flags flying in a three-decker, and to all the pomp and consequence of a glorious fleet, so captivating to the human fancy; and what is more, officers will no longer enjoy, particularly in the superior ranks, that comfort and accommodation which they now possess. It is true; the insignificance of an admiral's flag flying at the miserable mast of a steam boat cannot be denied; nor indeed, the generally insignificant aspect of a fleet of this character, compared to the gigantic aud noble structures of present warfare. But, whatever may be the ideal value of all this, we must recollect, in opposition to it, the enormous difference of expence in favor of a system of defence on the projected principle. The value or cost of a first rate, would build and equip forty steam vessels; either of which, singly, might be sufficient to subdue two of the former in action. The defence afforded to a coast, by even half a dozen vessels, would be more effective than that of a large ship of ten times the cost; or, were even a convoy of a hundred merchant vessels, protected by a line of battle ship, to be attacked by four steam vessels, the probability is, that they would be all taken and destroyed.

If there are more serious objections, or objections of more apparent solidity, brought forward by that class of persons to whom I have been alluding, they are almost entirely founded on misinformation respecting the subject; on inattention, or want of reflection respecting a mode of navigation, which is of recent date, as yet applied to limited purposes, and has not excited that degree of attention which it deserves. I must hope, that this treatise will have the effect of at least leading to a more careful consideration of the subject, though it should do no more; and I have no fear, but that the results will prove what I contemplate, in the abandonment of so pernicious a line of conduct. But we dare not renounce the attempt, at least; rather I fear, we have no time to lose, in commencing our courses of experiment, instruction, and study; while I also fear that we have already been culpably backward, and that our watchful rivals, enemies to become, have been some time labouring, in somewhat of secrecy, on this subject, anxious to get the start of us, and not unlikely to succeed in so doing, unless our government should come to a decision without further loss of time.

In fact, it is notorious, that both the French and Americans have been for some time training their officers in this new art of Steam Navigation; while the former abound not only in steam engines of our manufacture, but even in English workmen and engineers; a sufficient proof of their intentions on the subject, and of the importance which they now attach to it. If we do not absolutely know, that any other naval power has turned its attention to the subject, this, at least is probable, or we may safely infer, that conscious from experience of their inferiority as to naval warfare on the same old system, and hopeless of attaining, in an equal degree, the management of large vessels and fleets, they will gladly resort to a system more practicable, and more economical; and one, which from its requiring far less of what is called nautical knowledge, will bring their means to that equality which may render their future enmity at sea most hazardous to our superiority, if not to our existence.

This is a serious, but a true view of the subject; and without wishing to excite unnecessary alarm, not being an alarmist in disposition, it is very difficult to reflect steadily on the question, without some feeling of doubt whether the destiny of Great Britain, may not at length be involved in this very invention, whether its fate will not even be sealed, as soon as steam vessels shall supersede the present ones among the nations of Europe, and become, what the latter scarcely ever can, the general naval warfare of the world.

If we examine the present system of naval warfare, we perceive at once, that whatever effects may follow from the magnitude of the ships, and the force of their batteries, taking numbers also into consideration, the naval force of a nation must materially depend on its wealth. The most essential circumstance of all, however, is its nautical superiority, using that term in its widest sense, to distinguish every thing which constitutes the most perfect character of British Seamen; and this superiority, whatever other circumstances may unite to form it, is mainly connected with our extensive commerce, the real school of seamen; and however the term may be hacknied, the nursery of our navy. Now, it is in this that we possess advantages with which the continental nations, and above all, the less maritime ones, cannot easily cope, or can never come into competition at all: and thus is our naval superiority at present, or on the existing system, identified with the general causes of our prosperity, and secured to us as long as that state shall last. But the case may become far otherwise, should the system of naval warfare, which is here contemplated, ever become generally established, should it ever supersede the system of large ships managed by thorough-bred seamen. The general political consequences are easily inferred. Warfare at sea will approach more nearly to warfare on shore, or the differences between a military and a naval system will be small, compared to what they are at present. Any nation sufficiently wealthy to levy armies and fortify towns, may then build vessels and produce seamen, if seamen they can be termed, adequate to the management of a flotilla, and as well fitted for all the purposes of naval warfare, as their soldiers are for land service. The system in fact, will become a species of military, rather than a naval one, and they which should have been sailors, will be maritime soldiers, not seamen; and then will our superiority, as far as depends on seamanship, disappear; or we also shall become what they will be, and must learn to meet them on our own channel, and on their own shores, as we met them at Vittoria and Waterloo. It is equally evident, that the least maritime nations will then become capable of undertaking naval wars, as almost every instruction and discipline which their officers, men and vessels may require, will become practicable even in their own rivers and harbours, and on their own narrow seas.

Such a system, in fact, will be a renovation of the naval warfare of the Greeks and the Romans, and of that of the gallies of the Mediterranean and Baltic in later times, if under modifications; and a mere retrospective glance at those modes of warfare, at the naval actions between Rome and Carthage, at Actium, and in more modern days at Lepanto, will perhaps carry a clearer idea, of what will then become our naval service and our naval policy, than could be given by any mode of present detail. The essential points, or the fundamental character, it is plain, will be the same; what the variations may be, it would scarcely require much reflection to perceive, nor many words to state, if I had not already sufficiently dwelt on this view of the impending revolution.

If therefore we are entitled to expect that all those nations which have felt our superiority, and know its causes, as I have stated them, are likely to turn their attention to this subject, most needful is it that we should at least lose no time in attempting to acquire the necessary knowledge; that we may at least have a fair chance of preserving that power, which it is to be feared, would otherwise, not during many more years, remain the splendid and overwhelming one that has so long distinguished us among nations. And this is not to be acquired in a day, no, nor in a year; while I need but merely say, that they who are the most early and the most ardent in this race, are dangerous rivals, or may become so; and while also it must never be forgotten, that to lose a long possessed superiority, were it but once, at the commencement of a new system, is most hazardous; operating far more injuriously on the self-confidence of a nation, than any casual loss which it might then sustain would do on its wealth or security.

I am not prepared (and if I were, this introduction is not the place for it) to point out the exact nature of the political system which would be best adapted for the purpose, and which ought to be adopted at present; but I may remark generally, that an experimental squadron of steam vessels ought to be formed with as little loss of time as possible, and that an adequate portion of naval officers, with a certain number of men, should be embarked for the purpose of instruction. It may yet be long before the larger ships will be superseded, or rather, diminished in numbers; and many think it not probable that they will ever be really done away with; but in the meantime, the course of study as to steam vessels, should be directed chiefly to their use as auxiliaries, which is admitted on all sides to be essential; while the progress of time, or rather the event of a future war, would shew what the ulterior tendency of the system was, and what more would be wanted.

It appears to me, indeed, from what has already passed, that no large vessel would now be safe without an auxiliary protecting steam vessel, even should a war take place to-morrow; and it is a faulty feeling which *will not* see this, whether from pride, or from an undue, if in some sense excusable reliance, on a system so long the source of our strength and superiority. What the feelings of the nation may be, I am not however prepared to say; and if the government has hitherto shown any apathy or reluctance, I must hope, that under the present auspices, under Him, who now the supreme in peace, has also been supreme in war, this subject will not be long in meeting the attention, which, under the most sober views that can be taken of it, seems naturally and seriously called for.

Let me here also make one or two remarks, on that which always is and must be a primary object of anxiety, namely the coast defence. A very slight reflection will demonstrate to any one, that vessels of this description are best adapted for that purpose; and if any one has not yet made up his mind on this subject, let him reflect on the not very remote history of the Boulogne Flotilla, the alarms then entertained, and the doubts which were held as to our power of an adequate defence through large vessels. I need not repeat what was then said and thought, should that flotilla, however apparently contemptible, have attempted to make good its escape from port, and its landing in a calm which should have temporarily prevented our cruizers from acting, and above all, when a diversion in a remote part had drawn off our larger ships or the channel fleet. The case was possible then, and it is possible again; but had the threatened coast been provided with fifty or a hundred steam vessels, even of a small class, it is plain that even the most terrified might have slept in peace, and not only so, but that we should have saved the enormous expence incurred in the coast defence and fortifications, including those

Martello Towers, the price of which alone, would have constructed a powerful flotilla of steam ships.

Another remark is this; that we should without delay make such examinations of our most vulnerable coasts, as would ascertain at what points harbours could be constructed, for such vessels to take refuge in a storm, and to be ready as "*guarda costas*," or to form a floating fortification in case of a war. It is plain, that this will be indispensible under whatever view, even far short of any such event as a threatened invasion.

No trading vessel will hereafter be able to lie in the Downs, or in any open roadstead on our own exposed coast, if, as is probable, or rather, certain, the enemy shall adopt steam vessels; since any boat of this nature may run across from a French port under cover of night, even so as to plunder and destroy a shore, without the possibility of preventing it on our part, except through the adoption of such a flying and transferable defence.

But to pass from warfare, there are other reasons for extending the knowledge as well as the practice of steam navigation, more or less connected with the system of government, and with our commerce; and this extension will always be checked, until, by a far wider course of experiments, and through greater practice inspiring more confidence, the present doubts, inconveniences, or imperfections also are overcome. It is plain, for example, that this mode of navigation is especially applicable to revenue vessels, as it would always give them that superiority which is so essential to the effectual performance of their duties. Thus, also, it is peculiarly applicable to pilot vessels; while, having already been adopted for packet boats and mails of all descriptions, it is unnecessary to notice their acknowledged uses. The adoption of this system, has produced in Scotland in particular, a change in the activity, commerce, and aspect of the country, and, in the Highlands, in the very moral character of the people, as it ultimately will in their wealth, which has exceeded in magnitude, in a few short years, all that had taken place since the rebellion of 1745, great as that change was.

If we cast our eyes over a wider range, it will be no less easy to see what advantage will arise to commerce, or even to warfare, such as that warfare is in some of our foreign colonies or settlements, from a full adoption of the same system; while, as I must not occupy too much space in these introductory remarks, it will be sufficient to allude to the navigation of the Red Sea, or to that of the innumerable narrow straits, rocky shores, rivers and so forth, of the tropical countries, and to the piratical contests of the Arabic coasts. The history of the Burmese war indeed, and the more recent Greek warfare, are examples sufficient to prove what may be done and what gained by the more extended use of steam vessels, by rendering that systematical which has hitherto been casual, and by employing the use of a power, which we can scarcely doubt is at present almost in embryo.

Ought we not, ought not Great Britain also to take the lead? It has ever done so in every thing that belongs to the sea; it has done so in almost all that belongs to improvement in every thing; our officers have ever been the most distinguished in the world; our seamen have excelled all that ever ranged the ocean, whether in commerce or in war. But as in all else, if there is any thing to be learned, it cannot be acquired without teaching, it cannot be known without the means of instruction, and it cannot be made perfect without practice: and we do both ourselves and them injustice, when we do not afford them these means; for now shall we do them injustice if we suffer others to head them in the race; but bitterly also shall we repent it when it is too late.

At present, there is no such opportunity; not much for the men, none at all for the officers. Casually indeed, an officer may acquire a knowledge of the steam engine through private studies; and casually, a few also, by means of passages in packet boats, may learn to understand something about their powers and management; but, for many reasons, this must be very limited. Narrow enquiries into the engine itself are not permitted, or the answers are given to mislead; and the expence of a passage renders it impossible to navigate much with this sole view. The practice, in any case, they can not acquire, since they must not interfere; while the end is, as lookers on, to sit down with the disagreeable conviction that they have much indispensible knowledge to attain, and are cut off from the means of procuring it.

But I must conclude. The purpose of this work is rather to call the attention of officers to this subject, than to lay down a complete system; for whatever the Author, who has made it his study for five years, may have attempted by his own limited exertions, it has not been in his power, more than that of others, to acquire much knowledge without the means. It is a sketch of the more essential points, with suggestions drawn from his own practice and observation, as well as from experiments; being what is found actually existent in steam packets, but extended, under the supposition of a warlike or other application of their powers and properties. That this book will teach an officer his duty, without practice, is neither expected nor pretended: it can do little more than prove to him how much he requires to study the theory and practice, while it calls his attention to the principal objects that seem at present to demand it.

With respect to the moving force, it was indispensible to convey some general idea of that, by means of a distinct chapter on the engine; since without this essential knowledge, the officers in such a command could not be adequate to their trust; but as it was not held necessary to be very minute, the improvements of little importance to this object have either been slightly noticed, or passed over.

Here also, and on some other matters of detail, in the body of the work, the author has been restrained by the political fear, common in this country, in all matters of war, whether well founded or not, of communicating information to the enemy; and this therefore must be his apology for some omissions and obscurities: for those who wish a more full knowledge of the steam engine, the Author can refer to the three recent excellent works of Millington, Farey and Tredgold; books so complete and full, as to have rendered even an abridgement of them as impossible in a work of this nature, as it would have been superfluous.

But wherever the knowledge may be acquired, let naval officers never forget that it is indispensible; nor, by imitating the example of masters of packets, suppose that they can trust to their engineers. As well might the commander of a ship be ignorant of her construction and properties, how to make sail, work his ship, and, as has been told of former days, if tales say truth, trust all to the master and boatswain. Without the knowledge of the power in his hands, its extent, its limitations, and its dangers, he cannot tell when to moderate or push its force, or how far it should be done; he must ever be without confidence; he may, if rash or ignorant, destroy or lose his vessel; he is always at the mercy of those who are subordinate to him; and as is also possible, he may even be deceived by those in whom he must trust that which is the very heart and soul of his ship.

Enough. What the government intends to do, it is not my business to conjecture. But, it is my hope, that should this work not produce that effect which indeed I have no right to expect, it will at least serve to excite in the breasts of my brethren of His Majesty's Service, a general wish for the acquisition of the needful knowledge in the first place, and what I deem more essential, a general desire to influence the public opinion, and that of the government, by the declaration of their own.

Should it have this effect, it may be followed by solicitations for employment: and as the public opinion has always weighed, and must weigh, in our free and liberal government, those of naval officers cannot be without their effect on the Royal and Illustrious Personage who now directs, in almost a literal sense, the Helm; nor on that Man, to name whom, would almost be disrespectful; who, once the saviour of his country in war, and now its guardian in peace, knows but too well how intimately the prosperity committed to his charge is interwoven with the success of British arms, as well by sea as land.

ERRATA.

Page 84, line 10, *for* casted *read* catted.
85, — 26, *for* yawning *read* yawing.
94, — 2, *for* a starboard the helm fast *read* the helm made fast a starboard.
— *Note*, *for* stern *read* stem, *and for* checked, and *read* chocked or.
95, line 3, *for* wit *read* art.
96, — *for* scudding *read* sending.
97, — 19, *for* got ready every thing *read* every thing got ready.
120, — 1, *for* off *read* of.
140, — 12, *for* Cap *read* Captain.
Every where read Costigin *and* Trevethic.

A TREATISE, &c.

CHAPTER I.

ON THE STEAM ENGINE.

My aim in the following pages is to give as clear and concise an account as possible of the application of the power of steam, and other artificial agents to the moving of vessels upon the water, being one of those great improvements which the arts have derived from the cultivation of the sciences, within little more than the last half century. The vast importance of navigation, particularly to an insular and commercial nation, like Great Britain, is too obvious to need comment, and any substantial improvement that tends to diminish the risk and uncertainty of this art, cannot but be hailed with the most unequivocal approbation; and such is the application of steam to the purposes of navigating vessels. During a long series of years, the motion of vessels upon the surface of water has depended almost entirely upon the action of the wind upon their sails, or the application of manual labour to oars. The last of these operations is the most ancient, but is nevertheless the most certain, since the uncertainty of the wind is proverbial, while, on the contrary, if we have sufficient strength, the oar will take a vessel in any direction, even in opposition to both wind and current. The improvements that late years have produced in the forms of vessels, in the construction and application of sails and rigging, and in the manner of using them, have in no small degree removed the uncertainty of sailing; but cases still remain, and must for ever continue to do so, in which motion cannot be produced in this way, because no vessel can ever be constructed to sail in direct opposition to the wind, and when it altogether abates and an entire calm succeeds, the moving power is wholly suspended. In such cases nothing but the oar remains, and although this is always available in small craft, and may even be occasionally used to advantage for towing large vessels, yet the motion so produced is uniformly very *slow*, and is only obtained at a great expense of labour. Oars were formerly used with success in the galleys of the ancients, and are even yet retained for large vessels among some of the eastern nations, particularly in the Mediterranean sea. In these cases the rowers are seated at a very trifling height above the water, and are so numerous as to constitute the chief burthen of the vessel, consequently but little stowage room is left for the transport of merchandize, and from the room required by the men, the occupation in which they are constantly engaged, and the incumbrance of their oars, such vessels are much less fit for the purposes of war than the service of the merchant. The totally different form of British ships, with their sides highly elevated above the water, to enable them to ride in all seas, entirely precludes the use of oars, independent of which their room is required for more important purposes, and hence the wind (notwithstanding its uncertainty) has alone been resorted to for moving all large vessels, although it has in numberless instances produced the most dreadful disappointments, not only by delaying mercantile expeditions when their sailing has been of the utmost importance, but has defeated the most skilful and scientific manœuvres of our ablest and most experienced naval commanders, by the power upon which they depended for motion being suddenly suspended, or from changes of the force and direction of the wind taking place which could not be contemplated.

However useful and valuable the power of wind may be when it is blowing temperately in the right direction, still it must be confessed that if rowing, or any other artificial means of producing motion, could be uniformly maintained without that great expence and waste of room and labour which always accompanies it, it must be a great desideratum; and it will be shown, as I proceed, that all the several applications of steam and other artificial powers to the purposes of navigation approximate more or less to the operation of rowing.

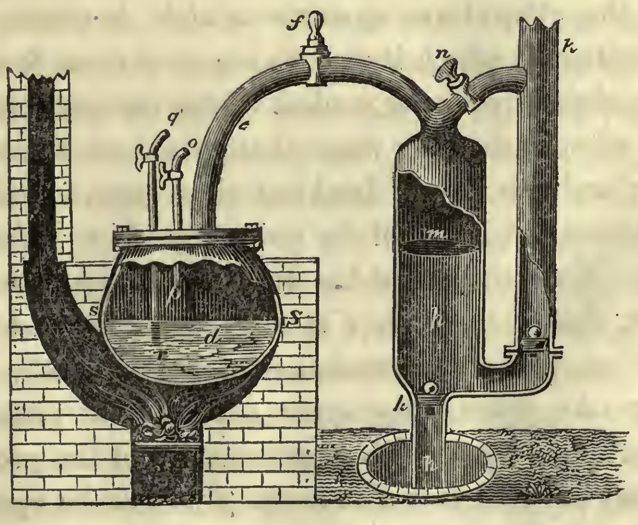
The application of the power of steam to the general purposes of navigation is so recent, and as yet is so little understood by those concerned in maritime affairs, as to plead a forcible excuse for the production of the present work; and for the same reason I feel that it would be by no means complete if I were not to preface it with such a general account of the nature of steam, and of the engines or machines in which it is employed, as will enable any one unacquainted with their construction to judge for themselves of their respective merits, and to form a just estimate of the truth and certainty of the truly philosophical principles upon which they act.

The great expansive force of steam, or that particular vapour that arises from the boiling of water and other fluids, has been long known to be so great as to bid defiance to the strength of every vessel in which it has been attempted to be confined: and upon this principle and the circumstance of steam being reconvertible into water again with astonishing rapidity whenever it is cooled, does the power of the steam engine depend. Water, in common with most other fluids, is subject to slow and spontaneous evaporation into the air at ordinary temperatures, and whenever it is so carried off, it must be previously formed into a vapour, which from the slowness of the process is invisible. But if the heat of the water is increased, the effect becomes visible and sensible, and at 212° of Fahrenheit's thermometer (which is the common boiling point of water in the open air at its mean pressure) the steam pro duced becomes equal in power to the pressure of the atmosphere, and hence the evaporation proceeds rapidly and is palpably visible. At this temperature, the steam of water occupies about 1800 times the bulk of the water in a cold state, or in other words, a single cubic inch of water, when made to boil, will produce 1800 cubic inches of steam, having a degree of elastic force equal to the air of the atmosphere, which at an average exerts a pressure of 15lbs. upon every square inch of surface. Hence, if these 1800 cubic inches of steam are received or retained in a vessel having but 900 cubic inches of capacity, the contained steam will be compressed into half its natural bulk, and it will exert a force of twice the power of the atmosphere, or 30lbs. upon the inch; and if the vessel had a capacity of only 450 inches, then the steam would exert a power of 60lbs. on the inch to burst open the vessel, and so on in proportion to the condensation that takes place. The power producible by confining steam and increasing its heat may therefore be increased, perhaps without limit, and yet notwithstanding this great force, the instant the steam is cooled down again below the boiling point it is completely annihilated, for the steam then re-collapses into its state of water, and of course shrinks into its original small bulk.

The first person who, it appears, thought of applying this valuable principle of the great dilutation of water by heat, and its re-condensation by cold, to the purpose of obtaining a motive power, was Edward Somerset, Marquis of Worcester, a nobleman of great mechanical acquirements, who lived in the reign of King Charles the Second, and to him the invention of the steam engine is therefore universally ascribed. The marquis did not, however, describe how the machine was to be formed or constructed, but merely published a small tract in 1663, called

"*A Century of the names and scantlings of such inventions as he had tried and perfected,*" and in which it stands as the sixty-eighth of his hundred contrivances, many of which appear so marvellous that it has been doubted whether they ever were invented or not, though this is in some measure set at rest by several of them having since been carried into effect. The first person, however, that produced an effective steam engine, on principles nearly accordant to those described by the marquis, was Capt. Thomas Savary, who, in 1698, obtained a patent for his invention, and tried it before the Royal Society of London in the following year, and as this engine affords an excellent example of the manner in which steam acts to produce power, I shall be the more particular in my description of the principles of this machine, which will elucidate what is to follow.

FIG. 1.



The annexed diagram, Fig. 1. copied from Professor Millington's Epitome of Natural Philosophy, in which a very copious account of the rise and progress of the Steam Engine through its various stages of improvement is given, is not a correct representation of the engine as constructed by Capt. Savary, but is on this account, the better suited to my present purpose, because it is divested of all those appendages which would make the machine appear complex and intricate. The steam is produced in a metal boiler *d*, which is fixed in a furnace of brickwork, with a chimney of sufficient height to cause the fire to burn briskly under the boiler, for the purpose of converting the water with which the boiler is about half filled, into steam. The boiler has a close top, or plate of metal screwed over it, so as to prevent the escape of any of the steam thus formed, except by the pipe *e*, in some part of which there is a cock *f*, by the opening or shutting of which, the steam can be confined within the boiler, or permitted to escape at pleasure. The further end of the pipe *e* communicates with the upper part of a strong hollow metal cylinder *p*, from the bottom of which proceed two pipes. The pipe marked *h*, proceeds down into the well or other situation, from which the water is to be raised, and the other turns upwards as at *k*, to convey that water to the elevated position to which it may be required to be forced. Each of these pipes are closed by strong conical valves, opening upwards as at *i* and *k*, in such manner that any water that gets above these valves cannot descend again; and *n* is a cock fixed in a short pipe, which forms a communication between the inside of the rising pipe *k*, and that of the cylin drical vessel *p*. Now after what has been said of the nature of steam, it will be obvious, that if the cock *f* is shut, while the water in the close vessel *d* is boiling, that an accumulation of highly elastic and powerful steam will soon take place in the upper part of that vessel, and which would burst open that vessel with great violence, if the process was long continued. And likewise that if the cock *f* should be opened while the steam was so accumulated, it would instantly rush through the pipe *e*, and fill the cylinder *p*, and the pipe *k* with steam, which by its heat and force would expel the atmospheric air previously contained in the cylinder, and drive it up the pipe *k*. The cocks *n* and *f*, being now shut, would leave the cylinder *p* filled with steam; and if cold water was now thrown upon the outside of that cylinder, or any other means resorted to for cooling it, the steam within it would be condensed, or be reconverted into water, which would occupy so little space at the bottom of the cylinder, compared to the steam lately within it, that its inside would be left nearly in a state of vacuum, and as the cock *n* is shut, and the valves both open upwards, no external air could get into that vacuous space by either of these openings, but the pressure of the atmosphere upon the surface of the water in the well, would drive that water up the pipe *h*, and into the hollow space *h*, as high as the letter *m*, or to a greater or less height, in proportion to the perfection of the vacuum produced, and provided the extreme height of the vessel *p*, did not exceed 33 feet above the surface of the water to be raised; and as the water so raised could not return back again through the valve *k*, of course the vessel *p* would remain nearly filled with water. As the cock *f* is kept shut during the whole time that the water is so rising, this allows time for the steam to accumulate again, and therefore, upon opening the cock *f* a second time, the steam will again rush to the cylinder *p*, which is nearly pre-occupied by water, and the elastic force of the steam, will therefore be exerted upon the surface of the water at *m*, and provided it be greater than the gravitating force of the column of water in the rising pipe *k*, it will drive the whole of the water contained in *p*, through the valve, and up the pipe *k*, so that the vessel *p*, will once more be filled with steam, which done, the cock *f* must be again shut, and the cock *n* opened for an instant, so as to let a momentary jet of cold water run from the pipe *k* into, or even on to the outside of the cylinder *p*, by which the steam will be instantly condensed, and a vacuum formed, which will be supplied with water from the well again, and thus, by keeping up the elastic force of the steam by a good fire, and alternately opening the cocks at *f* and *n*, may any quantity of water be raised at pleasure.

The height to which the water can be raised, must depend upon the force of the steam, and the strength of the materials of which the boiler and cylinder are formed. If they are sufficiently strong, steam of any required power may be obtained, by increasing the fire; and since the steam of water boiling at 212°, is just a balance to the pressure of the atmosphere, so if that force be doubled, or made twice as strong as the atmospheric pressure, it will exert a force equal to 30 lbs. upon every superficial inch of the boiler that contains it, or will have that tendency to burst it, and will at the same time, sustain a column of water 33 feet high, in any rising pipe as *k*, in the Figure. In thus stating the amount of pressure within the boiler at 30 lbs. upon every superficial inch, it must be understood that the sensible or actual pressure exerted, only appears equal to 15 lbs. upon the inch, because the external air of the atmosphere presses upon the boiler with a force of 15 lbs. on each inch, tending to crush it inwards, and consequently, this 15 lbs. of external pressure, must in every case be subtracted from whatever power the steam may be exerting within the boiler; and following this rule, it is found that when the steam within the boiler so exerts an actual force of 15 lbs. it will sustain and balance a column of water in the rising pipe *k*, of 33 feet in height. But the gravitating force of fluids is simply as their heights, consequently, to raise the column of water twice as high, or to 66 feet, the steam must be twice as strong, or equal to a pressure of 30 lbs. on the inch; to raise it three times as high, or 99 feet, the steam must be equal to 45 lbs. on the square inch, and so on in like proportion for greater or less heights.

In the actual construction of this engine, Capt Savary used two recepients like *p* for the water, in order to save time, because one was filling while the other was discharging its contents; he likewise adopted two boilers of different dimensions, the one being used to produce steam, while the other was kept constantly filled by a part of the water raised, and which was kept in a nearly boiling state by the same fire, and so arranged, that whenever the water of the steam boiler was nearly exhausted by evaporation, it was replenished on opening a cock, the compressed steam being used to force a sufficient quantity of the heated water into the steam boiler. Among other useful and ingenious contrivances which Capt. Savary introduced into his engine, may be noticed *the trial cocks*, for ascertaining that the steam boiler contained its proper quantity of water. As all boilers are opake, it would be impossible, without a contrivance of this kind, to know when they were properly filled; and this is quite necessary to the steady and uniform action of the machine, because if a boiler is too full, there may not be space enough left above the water to contain the steam as it is produced; and on the contrary, if the water should be nearly or quite exhausted, the steam might be produced so rapidly, as to become dangerous and unmanageable, or the lower part of the boiler might be melted, or burnt and destroyed. The trial cocks of the boiler are therefore so useful, that they have been retained through all the various improvements of the steam engine, and are shown at the letters *o p q* and *r* in Fig. 1. They consist of two small cocks of the common kind, screwed into the upper ends of two tubes of different lengths, which are so fixed into the top of the boiler, that the longest tube *r*, may project about 3 inches below what should be the general average surface of the water within the boiler, when properly filled, as indicated by the line *SS* in the figure. The shorter pipe *p*, fixed to the other cock, terminates below, at about 3 inches above the average water surface; consequently, whenever the cock *q* is opened, while the boiler is at work, the force of the steam ought to drive water up its pipe and discharge it, while the other cock *o* ought to discharge steam without water. Should the boiler at any time contain too much water, so as to cover the bottoms of both the pipes, then boiling water will be discharged by both cocks; and on the contrary, whenever the water is so far diminished, as to be below the ends of both the pipes, they will discharge steam only without water; consequently, by an occasional opening of these two cocks, the surface of the water may be regulated to within 3 inches above or below its proper height, as effectually as if it was at all times visible.

Many engines on Savary's construction, were erected in different parts of England, for supplying houses with water, draining fens, and other purposes; among which, is that of pumping water from ships, which Savary alludes to in a work he printed in 1702, entitled, the *Miner's Friend,* being a full description of his machine, and a recommendation of it to such as were engaged in raising water from deep mines; to which purpose it was applied in several instances, although attended with a great consumption of fuel, and considerable danger, arising from the very powerful steam that became necessary, whenever the water was to be raised from very great depths. Capt. Savary also first used the term, *horse power,* as a standard of comparison between what his engines did, and the number of horses required to produce the same effect.

It would be beyond the limits or intention of the present work, to enter into an historical detail of all the progressive steps which the steam engine has gone through, and I shall therefore confine myself to a brief account of its grand epochs of improvement. On this account, I shall pass over the researches of Doctor Papin, in France, and others in this country, with the mere notice, that that most valuable and important appendage to every steam boiler, *The Safety Valve,* originated with Doctor Papin, who also contrived the *two-way,* or as it is very generally, though improperly, called the *four-way-cock,* for distributing the steam alternately to the top and bottom of the steam cylinder, for the purposes, and in the manner which will hereafter be described.

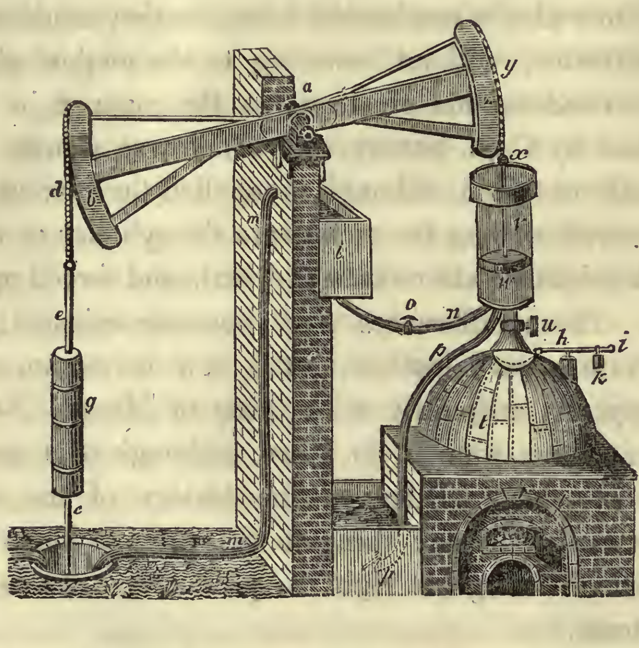
The safety valve is a metal valve, usually of the conical form, opening outwards, and fixed upon the upper part of every boiler. It should be of such capacity, as to give free and ample space for the escape of any superfluous steam that may be generated as well as for the whole steam of the boiler, whenever it is not wanted for working the machine, in which case the valve is opened. The safety valve is kept down in its place, so as to prevent the escape of any steam, by a weight placed immediately over it, or by a weight hung to a lever or steelyard, which presses upon the valve, and by which the action of the weight can be increased or diminished at pleasure. The former is by far the most eligible mode of loading safety valves, as they ought in every case to be made to act with a certain determinate power, proportionate to the area of the valve. Thus, for example, if the boiler of what is called a low pressure or condensing steam engine, has a safety valve, exposing 6 inches of surface, and it is required to work the engine with steam of the force of 4lbs. the weight placed upon the valve must be 4 times 6, or 24lbs. while, on the contrary, if it had been a high pressure engine, requiring steam of 60lbs. to the inch, then the weight on a similar valve must be 6 times 60, or 360lbs., a weight so large, that the steelyard application would most probably be adopted, although it is in no case so good or certain as the immediate weight, from the facility which it affords of doing mischief by shifting the weight further from, or nearer to the fulcrum, by which means the power of the steam may become much augmented or diminished, even without the knowledge of the engineer, and from which cause serious accidents have frequently occurred. In all engines to be used at sea this cannot be too much guarded against, and the safest precaution is to have two safety valves to every boiler, the one being loaded to the maximum power at which it is ever intended the engine shall work, and which ought then to be locked up in a case to which no one has access, while the other is left open, and at the discretion of the man attending the engine. By this means he will always have the power of diminishing the force of the steam, or letting it wholly blow off, but can on no account increase it beyond the fixed maximum of power, for on attempting to do so, the locked up valve will begin to act, and will thus frustrate any attempt to exert a dangerous or detrimental power on the machinery.

The foregoing account of the use and operation of the safety valve will also serve as a further elucidation of what is meant by the expression of steam having a certain power upon the square inch. Thus, if we conceive the safety valve to expose an exact square or superficial inch of surface to the action of the steam, and that steam rises the valve and escapes when the valve is loaded with 10 or any given number of pounds, (the weight of the valve itself being taken into the account,) such steam would be said to be steam of 10 or any other given number of pounds force, and of course as much power as the steam would exert upon each inch of a safety valve, so much would it also have upon every superficial inch of the surface of the boiler to tear or burst it open.

Next to the engine of Savary, the first important step in the improvement of this machine was effected by Messrs. Newcomen and Cawley, two tradesmen of the town of Dartmouth, in Devonshire, who obtained a patent for their invention in 1705. The public was fully aware of the vast importance of the new agent for producing power, which had been brought into existence by Capt. Savary, but at the same time, the danger of carrying it into effect, particularly as it was at first used without a safety valve, and the many serious accidents that had occurred, prevented this important invention being used to the extent to which it would otherwise have been carried. Messrs. Newcomen and Cawley, therefore, at first turned their attention, more to the safety than the power of the machine, and in so doing they not only produced an engine of perfect safety, but of astonishing power at the same time. They had watched the operation of Savary's engine, and having noticed the astonishing rapidity with which a vacuum was formed in the water cylinder, whenever it was suddenly cooled after having been previously filled with steam, the happy thought occurred to them of producing the motive power through the agency of this vacuum, by calling in the aid of atmospheric pressure, instead of the expansive force of steam; and thus they produced a machine, which they called *the Atmospheric Steam Engine*, a name so appropriate, that it has ever since been retained. In the prosecution of their invention, they however met with some difficulties of a legal, instead of a mechanical kind, for they could not bring their machine to perfection, without resorting to the method of producing a vacuum by the condensation of steam, in the manner in which it had before been done by Capt. Savary, and which was secured to him by his patent previously obtained, although he applied the vacuum to a different purpose, viz. merely raising the water into the cylinder or water receiver, in order that it might be afterwards expelled, and forced up by the force of the steam. These differences were however adjusted, by admitting Capt. Savary into a participation of the new invention, and his name accordingly appears, conjointly with those of Messrs. Newcomen and Cawley, in the patent granted to them; although it is generally stated by all those who have written on the history of the steam engine, that he did not contribute any thing to the present important improvement, further than ceding his right to producing a vacuum by the condensation of steam.

The steam engine as produced by Newcomen and Cawley, assumed a perfectly new character and form, since a truly bored cylinder, having an air tight piston working in it, and the great beam or lever, now so well known, were for the first time introduced; and whatever might be the power required from the engine, still no steam was ever required of greater power than 4 lbs. to the inch, or 4 lbs. more than atmospheric power, consequently the operation of the machine was rendered quite safe and harmless; at least, as to the danger of explosions from using highly elastic steam. The form in which Newcomen's engine now appeared as described in the same work before referred to, is as follows. The boiler for producing the steam, is set in brickwork as before, and has a powerful fire underneath it, as shewn at *t* in Fig 2.

Fig. 2.



v is a cylinder, truly bored in the inside, having an open top and close bottom, by which it is connected to the top of the boiler by a short pipe *u* containing the steam cock. A piston *w* is made to move up and down in the cylinder in an air-tight manner with as little friction as possible, by packing its edge with loose hemp, and covering its upper surface with water. The piston rod *x* is attached by a chain *y* to the circular part *z* of the apparatus *z a b*, called the ***Beam of the Engine***, and which was now first introduced. The engine beam was formed of strong timbers firmly framed together, strengthened by iron bars and straps, and constructed so as to move and balance upon the iron gudgeon or axis *a* supported upon a strong brick wall *c*, being usually one side of the house containing the engine, and so that the end *z* of the beam was within the building while the end *b* projected into the open air. Another chain *d* is attached to the external circular end *b* of the beam, and from this the piston rod *e e* of the pump to be worked in the well or mine below is suspended. This last piston rod is attached to any of the various pumps, which raise water by the ascent of their pistons, because the power of this engine is in the up stroke of the end *b* of the beam. When the depth of the well is considerable, the piston rod *e e* will itself be sufficient to act as a counterpoise, but should this not be the case, then weights as at *g* must be added to the rod until it rather over-balances the weight of the steam piston and rod *w*, *x* and its friction in the cylinder, so that when the cock *u* is opened, and air is permitted to pass into the lower part of the cylinder *v*, the piston *w* may rise to its top without violence; but should the pump piston rod *e e* be so heavy as to draw the steam piston *w* up too violently, or to draw it up against the pressure of the atmosphere which will act upon it when the cock *u* is shut, then counterpoise weights must be added to the steam piston *x*, or the end *z* of the beam, until the machine is properly adjusted, which will not be the case, until the steam piston *w* rises equably and gradually upon opening the cock *u* to admit air; for during this adjustment it is presumed that no fire is under the boiler, and consequently that no steam is produced. A safety valve opening outwards is placed upon the upper part of the boiler as at *h*, and this is kept closed by the lever *i* and weight *k*, which by being placed nearer to, or further from the valve, will act with more or less power, and will permit the escape of the steam, should it at any time become too violent. Having so far described the form of this engine, its mode of operation will be found very simple. Thus to set it to work the boiler *t* must contain its proper quantity of water, and the cock *u* being opened the steam piston *w* is to be drawn downwards until it touches the bottom of the cylinder, by which all the air previously contained in it will pass downwards through this cock *u* into the boiler, and from thence will escape by the safety valve *h*. The cock *u* is now to be shut, consequently the piston *w* will be prevented from rising by the pressure of the external air upon it. In this state the machine stands, until by lighting the fire, steam is produced of rather more power than is equivalent to the pressure of the atmosphere, when upon opening the cock *u*, in a greater or less degree, that steam will enter the cylinder *v*, and permit the piston to ascend, partly by the force of the steam, but chiefly in obedience to the counterpoise weights *g*, so that the velocity of motion may be regulated to the greatest nicety. Just before the piston reaches the top of the cylinder, the steam cock *u* must be shut, by which the beam will become stationary, and the cylinder will remain full of steam until it is condensed by cold. In order to effect this condensation a small cistern *l* is fixed in an elevated position, and is supplied with cold water by a pipe *m m*, proceeding from the pump in the well, and *n* is another pipe proceeding from the bottom of the cistern *l* into the bottom of the cylinder *v*, so that by opening the cock at *o* a small quantity of water is let into the cylinder to condense the steam and produce a vacuum, when the pressure of the external air will act on the top of the piston *w*, and cause it to descend with a force proportionate to its area; and as this pressure will amount to very nearly 15 lbs. upon every superficial inch, it will be fully competent to raising the end *b* of the beam, and any pumps or other load that may be attached to it; for if the cylinder is but 2 feet in diameter (which is by no means large for such an engine) the area of its piston will contain 452 inches and three quarters, which multiplied by 15 lbs. or the pressure upon a single square inch amounts to no less than $6785\frac{3}{4}$ lbs. and deducting 1-fourth for the friction of the machine, the effective force remaining to operate on the piston will be $5089\frac{1}{2}$ lbs.

This engine was at first much less perfect than above described, and had many defects and inconveniences which were gradually removed; for the condensation was in the first instance performed on the outside of the cylinder, instead of admitting the water within it, and the greatest nicety and attention on the part of the workman was necessary in turning the two cocks at the precise necessary periods; for if the steam was permitted to enter the cylinder for too great a length of time, the piston would be carried above it, and would be blown out of its place; while on the contrary, if the cock was not opened soon enough when the piston was descending, it would strike against the bottom of the cylinder with such force as to break it to pieces. The steam by which the engine is worked is also constantly mixed with a certain portion of air which is disengaged from the water in boiling, and this together with the cold water injected into the cylinder for producing condensation was found to accumulate so fast that a pipe became necessary to lead into a cistern below, for their discharge. Such a pipe was accordingly adopted, and was made to terminate in a valve at its lower end, to preserve the vacuum, and this valve from the peculiar noise it was found to make, was called the Snifting Clack. The situation of this pipe and valve are shewn at *p p* in the figure. The water, and any air the cylinder might contain were thrown out at this valve by the last effort of the piston in descending, before it reached the bottom, and thus the cylinder was cleared between each fresh introduction of steam. This engine performed exceeding well in the first instance but was very much improved within the first seven years after its invention in 1705. Some of its improvements it is true were accidental, for that of condensing by the injection of cold water into the cylinder instead, of applying it externally arose from some holes being left in the piston of an engine which permitted the water placed upon it for keeping it air-tight, to run through and condense the steam: and the great difficulty of opening the cocks at the proper moment was conquered by a boy named

Humphrey Potter, who attached some strings and catches to the cocks of an engine he was employed to work at Wolverhampton, in order to release himself from the trouble of attending to them, and which, although clumsily contrived, performed their office very well, and gave the first idea of that machinery called *Hand Geer*, by which the valves or cocks of all steam engines are now worked, by the immediate action of the engine itself.

This description of Engine could not be said to be in a perfect state before the year 1718, when Mr. Henry Beighton, of Newcastle upon Tyne, erected a powerful steam engine on this principle, with many important improvements, relating however chiefly to the working parts, and the manner of admitting and shutting off the steam, by means of what he called a Plug Tree, which acted upon certain levers and catches for working the valves; the fixing of the cylinder was likewise much improved by him, but still it was placed immediately over the boiler as at Fig. 2. He likewise first applied a small forcing pump to throw water into the boiler, in order to supply the waste of evaporation, and the machine, though not altered in principle, was considered so perfect with his additions, that further improvements were scarcely expected in it, and it remained unchanged, though almost universally adopted, for nearly half a century under the name of Beighton's Fire Engine.

After the account that has been given of the enormous force that is brought into action in the cylinder of one of these engines when at work, the impropriety of fixing such a cylinder upon a boiler, supported over a large fire, must be apparent; for however strong the brickwork of the fireplace may be built, still it must be subject to rapid decay from the action of the fire, and whenever this occurs, a derangement of the adjustment of the whole machine will follow; and notwithstanding the improvement of Mr. Beighton, who supported his cylinders between strong timbers, so as not to let them depend altogether upon the brick work of the boiler, still there was so much vibration that the furnace was soon shaken and destroyed. The piston in its up stroke would actually lift up the entire boiler and cylinder as much as the springing of the timbers would allow, and would depress and replace them at the return of the stroke. The above-mentioned defect was however removed in some cases, by resorting to the former construction of Captain Savary, that is to say, placing the cylinder beside the boiler, instead of above it, and bolting it down to a solid and massive block of brickwork and masonry, having no connection with the fire. By this means, not only more stability was insured, but the former great height, and consequent expence of the engine-house was dispensed with.

The steam engine was at this time considered so perfect, that the attention of men of science was not so much directed to its mechanical improvement, as to the means of preventing its consumption of fuel; for the engine at this period was never used, except on a large scale, and whenever it was introduced it was found to consume a prodigious quantity of coals. The nature of heat and steam were not however sufficiently understood to show that the radical error was in the engine itself, and not in the boiler as was afterwards discovered, and accordingly about this period, many experiments were tried on different forms of boilers to produce the greatest quantity of steam with the least fuel.

It was soon ascertained, that that form of boiler which exposed the greatest quantity of surface to the action of the fire, and did not permit its heat to pass up the chimney until nearly the whole of its power had been exhausted, was the best, and accordingly in some of the boilers constructed under the direction of Mr. Smeaton, the flame and smoke had to pass through a complete labyrinth of channels; but the number of angles and sharp corners that were thus exposed to the action of the fire, not only rendered the boiler liable to be burnt or destroyed, but made its construction much more expensive, without producing a proportionably beneficial result, in consequence of which the form of engine boilers is now much simplified, and even in those of the largest engines, Messrs. Watt and Boulton employ but one central flue or chimney through the boiler, which from its resemblance in shape to the body of a waggon with a tilt thrown over it, has very generally obtained the name of the waggon boiler. It is made of an oblong shape with a semi-cylindrical covering, which is the only part that projects and is visible above the brickwork of its setting. The size of these boilers varies from 5 feet to above 20 feet in length, according to the power of the engine to which they are applied, while their width and depth is made according to certain established proportions. Thus for what is called a 20-horse power steam engine, the boiler is usually 15 feet long by 6 feet wide, so as to have 90 superficial feet on the surface of the water, while the height from the bottom to the top of the dome is 7 feet. A boiler for a 14 horse engine, in like manner, exposes about 60 feet of surface; and one of 80 horse power, would expose 360 feet, and so on. The fire is made on bars underneath it, extending about half the length of the boiler or rather less, and under them is the ash hole for the cinders to fall into; the brickwork of the fire-place rises above the bars at their extreme ends, so as to form what is called the *bridge,* which stops the fuel from entering the flues and throws the flame more immediately against the bottom of the boiler, after which it is conducted by an arched flue into the metal tube or flue passing through the entire length of the boiler under the surface of the water to be boiled, and by this the flame and smoke is brought to the front, from whence it is carried back again by two horizontal flues, running along the two sides of the boiler, and which conduct it into a rising chimney. An oval cast iron plate is usually fixed with screw bolts and nuts over a hole in the upper part of every boiler, being of sufficient size to permit a man to pass through it for cleaning, repairing, or examining its inside, on which account this orifice has obtained the name of the *Man Hole:* and a cock for emptying the boiler of its water, or drawing off any portion of it that may be superfluous, is always fixed in the lower part of the boiler, and projects through the brickwork.

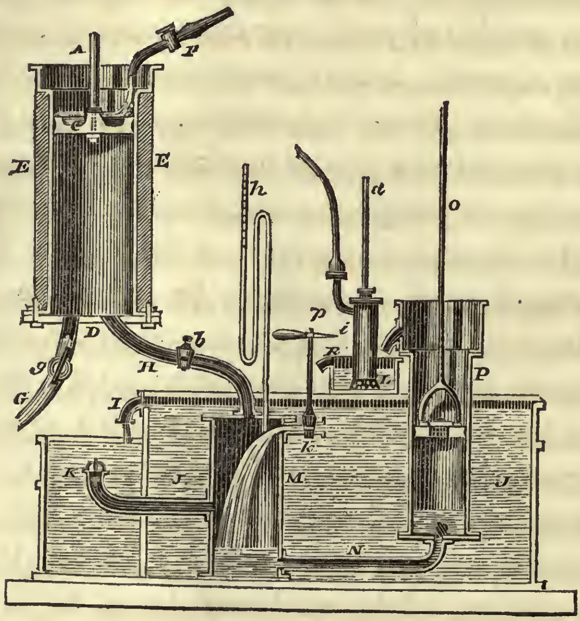
No alteration however in the form or construction of boilers, could remove the radical defect which still existed in all steam engines, namely, the immense loss of power and of fuel which was indispensible, on account of the recipient or cylinder requiring to be first heated, and then cooled, to produce its alternate actions. Thus it will easily be perceived from the very nature of steam, that to produce any powerful action in the recipient *h* of Savary's Engine, (page 5) that recipient must be as hot as the steam itself, otherwise the steam would be condensed and incapable of producing the effect of forcing up the water; while on the contrary, to produce a vacuum, and refill the recipient with water, it must be rendered so cold, as to annihilate the vapor: hence, much more steam is necessary to heat the vessel, than to raise the water, and all that heating must be thrown away, since between each effort it must be cooled again. The same reasoning applies (though in a less degree) to Newcomen's Engine, for in that machine, the cylinder must be hot enough to permit the steam to exercise an elasticity equal to the pressure of the atmosphere, which it will do at a much less temperature than is necessary in Savary's Engine, and it must be cooled again to produce the vacuum that is to follow. From accurate experiments that were afterwards tried, it appeared that three times as much steam as the cylinder would contain was wasted in giving it sufficient heat to permit a fourth cylinder of steam to produce its action, and as no steam can be produced without a proportionate consumption of fuel, so three times as much coal was burnt to work Savary's engine, as would have been the case if the intermediate cooling could have been dispensed with.

It was this subject that first engaged the attention of the justly celebrated Mr. Watt of Birmingham, to whom this nation owes so much for the improvement of this important machine. He did not, like his late predecessors, look to the minutiæ of mechanical construction in the engine or its boiler, but to their principles of action. His first experiments in **1763**, were directed to the prevention of the radiation of the heat of the cylinder from its outside, and with this view he cased his cylinder with wood, as being a slow or bad conductor of heat; imagining, that if the outside of the cylinder was kept hot, a sufficient cooling might take place within it to produce the desired effect, but in this he was disappointed. The alteration certainly produced a saving of fuel, but at the same time, the cylinder could never be sufficiently cooled, to produce a perfect vacuum, consequently, a diminution occurred in the power of the engine, that was fully commensurate with the saving of coals. His next attempt was truly philosophical and beautiful, and eventually led to the important improvements which he shortly after introduced. It was an experiment to ascertain whether the condensation could not be effected in a separate vessel connected with the cylinder, instead of in the cylinder itself. With a view to try this effect, he placed a hollow air-tight vessel beneath the steam cylinder, and connected with the bottom of that cylinder by a pipe having a stop cock in it. This new or lower vessel, was immersed in a cistern of cold water, to keep it cool. While the steam was entering the steam cylinder to raise the piston, the cock was shut, but on being opened when the piston had reached its greatest elevation, a portion of the steam was forced by its own elasticity into the lower vessel and condensed, by which a sufficient vacuum was produced to draw all the rest of the steam into it, to be likewise condensed; and thus it was found that by this simple and admirable contrivance, as perfect a vacuum as could be required, was produced, without at all lowering, or affecting the temperature of the steam cylinder.

Mr. Watt, had however many difficulties to contend with, before this contrivance was brought into a perfect and practicable form, in consequence of which he did not obtain his first patent till 1769. Thus, for instance, his newly introduced vessel, which from the office it had to perform, he called a *condenser*, very soon became filled with the water produced by condensation of the steam within it, and of course it required to be frequently emptied in order to continue its operation. The water in which it was immersed, also became so hot, by absorbing the heat of the steam, as to be incapable of producing the necessary condensation, unless changed at short intervals; but by perseverance he soon overcame these and all other difficulties. Several expedients were tried for their removal, but at length he adopted two pumps in addition to the parts of the engine as already noticed; such pumps deriving their motion from an immediate connection with the main beam or lever of the engine. The first of these pumps, which was of small dimensions, he called the *Air Pump;* its office being to draw off any air and condensed water that might accumulate in the condenser, to the lowest part of which it was connected by its suction pipe, and the other pump drew water from an adjacent well constructed on purpose, and delivered that water in its cold state into the cistern in which the condenser was placed, and as that water was kept constantly running to waste from an opposite part of the cistern, so the greatest possible coldness of the condenser was at all times insured.

The general arrangement of Mr. Watt's engine at this period, as above described, is shown at Fig. 3, but the real disposition and manner of fixing the parts is not there attended to, 1st. because in the real engine one part comes before and obscures another, and 2ndly. the arrangement was altered as the engine became further improved. Still, however, all the parts included in this figure were retained, with certain alterations, and the use of it is, therefore, rather to make the reader acquainted not only with the names of these parts, but with the offices they have to perform, so that in afterwards describing the actual form of the engine, it will merely be necessary to call them by their names, without further description. In this figure, the steam is supposed to pass or be shut off in its passage through the pipes, by cocks, as before described, instead of by the valves and other contrivances used in engines, as will hereafter be particularly noticed.

Fig. 3.



G is *the steam pipe* communicating from the boiler in which the steam is generated to the lower part of the steam cylinder *D*, and *g* is a cock for admitting or shutting off the steam, and therefore called *the steam cock* or valve. *C* is the piston moving in an air-tight manner, upwards and downwards, in the steam cylinder. *A* the piston rod, the upper end of which is not shown in the figure, but is supposed to be connected with one end of an engine beam, as at *y* in Fig. 2. *F* is a cock and pipe leading to an elevated cistern, by which a little water can be discharged upon the top of the piston to keep it air-tight. *E E* section of the wooden casing, *or jacket,* as it is technically called, that is applied round the exterior of the steam cylinder to retain the heat. It is made in separate staves, like a barrel, and is held in its place by iron hoops that encompass it. *H* the *eduction pipe,* leading from the bottom of the steam cylinder to the upper part of *the condenser M,* which is a hollow upright cylindrical vessel, fixed below the steam cylinder in a large cistern of water *J J,* called the *cold water cistern,* and which should be deep enough to permit every part of the condenser to be covered with water; *b* is a cock called the *eduction cock,* or valve, for opening and shutting off the connection between the steam cylinder and the condenser. *P* is *the air pump,* which is also fixed in the cold water cistern, but without any internal communication with the water it contains. This pump is of the common construction of lift or household pumps, except that it requires better work, and its valves are of metal instead of leather, on account of the heat of the water that has to pass through them. Its lower valve, situated any where between the bottom of the working barrel and that of the condenser, is called *the foot valve.* *O* is the piston rod of the air pump, the upper end of which is supposed to be connected to, and worked by the engine beam. *N* the suction pipe of the air pump communicating with the bottom of the condenser *M,* in order that it may draw off or pump out any air and water it may at any time contain, and as that water will always be in a hot state when the engine is at work, it is caught or received in the small cistern *L,* which on this account is called *the hot water cistern.* A common lifting pump is also placed by the side of the cold water cistern *J J,* having its piston rod so connected with the beam of the engine that it may be worked by its motion. This pump is not shown in the figure, but delivers its water into the condensing cistern, and it is constantly running to waste by the spout at *I,* so that the condensing water is always changing, and is by this means kept cold. The superfluous hot water is in like manner conveyed away from the hot water cistern by a spout at *R*, from whence it flows into a waste drain. The other objects in this figure refer to more recent improvements upon the machine, and will therefore be afterwards noticed.

The construction of this machine is, with the exception of the air pump, cold water pump and cisterns, exactly the same as the engine of Newcomen, already described, and therefore little need be said as to its operation, for if the piston *C* is at the bottom of the cylinder and the steam valve *g* be opened, steam will rush into *D*, and permit the piston to ascend in obedience to the counterpoise weights at the opposite end of the beam, and at the same time the piston of the air pump will rise, and produce a partial rarefaction in the condenser. As soon as the piston has got to its proper elevation, the cock *g* is to be shut and the cock *b* opened, when the steam in the cylinder will rush into the condenser and be condensed, thereby producing such a vacuum as will cause the piston to descend, when the cock at *b* must be shut, and that at *g* opened, to produce a second rising of the piston *C*, during which the air pump *P* will draw off any condensed water that might have been deposited in the condenser *M*, and will deliver it into the small cistern *L*, thus preparing the condenser for making a second vacuum, which it is enabled to do by the cold water pump keeping the cistern *J J* constantly replenished with fresh water. To increase the power of condensation, Mr. Watt found it necessary to place a cock, as at *k*, for admitting a small stream of water to run from the cistern into the interior of the condenser, in such a direction as to meet the steam as it flowed in from the eduction pipe, by which means the condensation was not only rendered more perfect, but at the same time much more rapid than by the mere immersion of the condenser in water. This cock is called *the injection cock*, and it may be shut or opened to a greater or less degree, to regulate the admission of the injection water by the prolonged handle and lever *p, i,* one end of which is made with a sharp point to serve as a pointer or index to a circular scale of divisions engraved on a brass plate fixed beneath it, to indicate the opening or quantity of injection water that is at any time admitted.

In this state of the steam engine, it was ascertained that it required little more than half the fuel to work it, which was necessary before these improvements were made, and therefore if Mr. Watt had stopped, even at this point of perfection, he would have gained a great desideratum. His experiments had clearly demonstrated to him the importance of keeping the cylinder as hot as possible, and this he saw was not completely effected, because the steam cylinder was open at the top to the external air, and consequently whenever the piston descended the whole inside of the cylinder became exposed to the air, and a portion of the water thrown by the cock F upon the piston, and which adhered to the sides of the cylinder, became converted into steam, whereby he was convinced the cylinder must be much cooled, for he was aware that the steam could not be produced but by an abstraction of heat from the cylinder, and he therefore next applied himself to the removal of this inconvenience, which he soon conquered in the most simple and effective manner. He knew that the mean or ordinary pressure of the atmosphere then used to depress the piston, operated at the rate of 15 lbs. upon every square inch of its surface, and could not be augmented or increased in any way. He also knew that the steam let in under the piston, to produce its elevation, must be at least equal to, if not superior to atmospheric pressure, or it would not have answered the purpose. If, therefore, that steam could be applied above the piston, instead of the air of the atmosphere, it was evident that it was an equally powerful agent, and might be made a much more powerful one by a slight increase of temperature, while it could in no case produce the cooling of the cylinder which he was now trying to guard against. This beautiful and beneficial application of the steam he obtained by putting an air-tight lid or covering to the steam cylinder, in the center of which was a contrivance now well known under the title of a *Stuffing Box,* through which the rod of the piston, when made a true and perfect cylinder with a polished surface, could slide upwards and downwards in a perfectly air-tight manner. This and a trifling alteration in the disposition of the pipes, and their cocks or valves for regulating the passage of the steam was all that was necessary, since all the other parts of the engine remained without alteration. The vacuum was formed under the piston in the lower part of the steam cylinder, by condensing the steam previously admitted in the manner that has already been described; but instead of permitting the pressure of the external air to drive the piston down into the vacuum so formed, that external air was completely shut out and excluded, and a cock or valve was opened, which permitted steam to pass from the boiler to the upper part of the cylinder above the piston, where it performed the office before assigned to the air, and the piston was carried down. The piston had next to be raised by the action of the counterpoise weights at the opposite end of the beam, but before they could act, the steam that had taken possession of the cylinder must be condensed or be permitted to escape. And here again we have another admirable instance of contrivance, for instead of permitting this quantity of steam to be wasted, Mr. Watt placed a pipe of communication between the top and bottom of the cylinder, with a single cock or valve in it, that was opened as soon as the piston reached the bottom of its stroke, and thus its upper and under sides were instantly reduced to a state of equilibrium as to pressure, and all further motion was stopped. The counterpoise weights could now act, and by raising up the piston all that portion of steam that was above it passed by this pipe to the under part of the cylinder, and became the quantity of steam that was next to be condensed to produce a vacuum, which was instantly produced by opening the eduction cock or valve, and making a communication with the condenser, previous to which the cock in the pipe leading from the top to the bottom of the cylinder was of course closed, when the upper side of the piston now elevated was prepared to receive a second quantity of steam from the boiler to produce its depression.

Fig. 4.

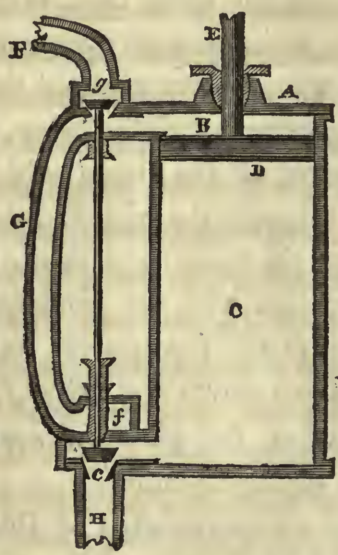


Fig. 4 will serve to show the manner in which this change of position of the same quantity of steam is effected. B C is a section of the steam cylinder and D its piston, the rod of which E passes through an air-tight stuffing box in the close cylinder top A. The steam is brought from the boiler by the pipe F, which communicates with the upper part B of the cylinder, and likewise with the pipe G, which goes to the lower part of it, and H is a pipe leading from near the bottom of the cylinder to the condenser placed below, but not shown in the figure. *g* is a conical valve, by the falling or shutting of which all flow of steam from the boiler to the cylinder is cut off, and *c* is a similar valve, which when shut, cuts off the communication between the condenser and the bottom of the cylinder. These two valves are both fixed on the same spindle, and rise and fall together; and when they are both lifted, the condenser will form a vacuum under the piston, while the steam is entering above it at B, and will therefore cause the piston to descend, and having done so, these two valves are closed, and a third valve *f*, which usually slides by a stuffing box upon the rod connecting the other two, is opened by drawing it upwards, when there will be an immediate open communication through the pipe G, between the upper and lower parts of the cylinder. The counterpoise weights at the opposite end of the beam, will now operate to raise the piston, and as it ascends, all the steam which had lately been introduced above it, will pass through the pipe G into the lower part C of the cylinder, where it will remain to be condensed, and form a vacuum the instant that the communication with the condenser is again opened; and this is done as soon as the piston reaches the top of the cylinder, for then the plug-tree machinery shuts down the valve *f*, and immediately afterwards opens *g* and *c*, when the piston descends again, with the full force of the steam that is acting upon it.

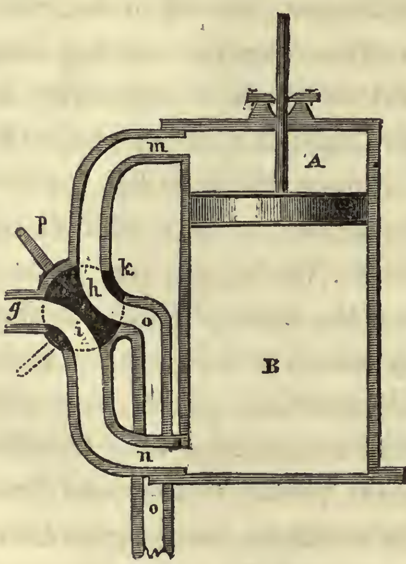
It will be evident from a consideration of this truly beautiful arrangement, that notwithstanding the action of the atmosphere is altogether excluded, yet no more steam is taken from the boiler, than in the former mode of working, and inasmuch as the cylinder is never cooled below the temperature of the steam; so a much less quantity will in reality be required to produce the same quantity of power.

This engine, from its great economy in fuel, soon superseded those of Newcomen, and all others that had preceded it, and it was used to a great extent for pumping water out of deep mines, an operation for which it is particularly fitted, because its action is exactly similar to the atmospheric engine, notwithstanding that the pressure of the atmosphere is wholly excluded. Like that machine, its powerful action is only during the descent of its piston into the vacuum, its elevation being slow, and produced only by the preponderance of the counterpoise weights. It is therefore not fitted for the purpose of producing rotatory motion, or that continuous action that is necessary for impelling manufacturing machinery, or for moving vessels. On this account, I have been the less particular in my description of its parts, and its mode of working, though I should have felt that I had left a great chasm in my description of the rise and progress of this important machine, had I omitted a notice of this stage of its improvement. It is usually denominated Watt's single acting engine, to distinguish it from the atmospheric engine, and from its next stage of progression, which I shall now proceed to describe.

Hitherto, the steam engine from the varying velocity and power of its up and down stroke, and its want of regularity in other respects, had never been applied to give regular rotatory motion to machinery, although ineffectual attempts to produce this desirable improvement had been made by many persons. Here again, we have another instance of the zeal and persevering industry of Mr. Watt; for very soon after he had enclosed his cylinder and excluded the atmosphere, he devised a means of making the steam act alternately above and below the piston, while the vacuum was in like manner made to change places, thus constituting a completely double engine in the same magnitude, with the advantage of having the up and down strokes of the piston, of the same force or power, and with equal velocity, while the counterpoise weights became useless and were discarded, so that the motion of the machine was produced by the steam alone, acting within the cylinder, and without any external aid or auxiliary whatever.

After the explanation already given, no difficulty will occur in understanding the construction and operation of the *Double Acting Steam Engine,* as this modification of the machine is called, but in considering it, it will be necessary to describe some of the contrivances that have from time to time been made and adopted for producing a proper distribution of the steam and vacuum above and below the piston. Cocks have hitherto been spoken of for this purpose, but their great friction, when made upon a large scale, excludes their admission into engines of any magnitude. The four-way cock of Dr. Papin, before alluded to, is however frequently used in small double engines, and is so simple in its operation, that I shall adopt it in my present description of this form of machine, which is represented in the annexed Fig. 5.

Fig. 5.

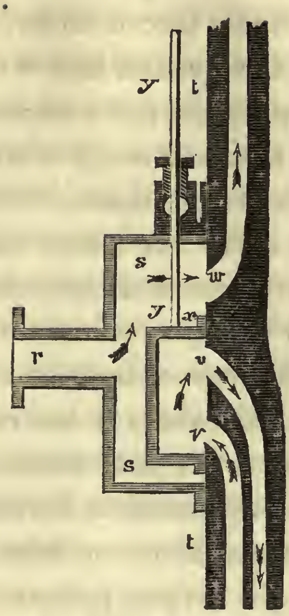


Let A B represent a section of a steam engine cylinder, with the rod of its piston, working as before, through an air-tight stuffing box, and *g* the pipe that brings steam from the boiler, and which terminates near the cylinder, in the four (or rather two) way cock *h i k* and the pipes *m n o*, which are drawn much larger than they should be, in proportion to a cylinder of the size of A B, that their parts may be distinctly seen. P is the handle or lever for turning the cock when required. This cock is constructed exactly in the same manner as other cocks for fluids, and consists of a conical plug or pin, (indicated by the black circle in the figure,) ground very truly to the body of the cock itself, but instead of there being a single straight hole or passage through this plug, as in common cocks, there are two curved passages *h* and *i*, which gives the outside of the plug the appearance of having four openings, each appearing one quarter of the circumference apart; so that as the cock is represented in the figure, steam coming from the point *g*, would pass through the opening *i* in the plug, and would be delivered into the pipe *n* at right angles to its first direction, instead of keeping directly onwards to *o*, as would be the case in a common cock. From the pipe *n*, the steam passes immediately into the lower part B of the cylinder, and consequently, would drive the piston upwards. At the same time, it will be seen that there is an immediate communication between the upper part A of the cylinder, through the pipe *m* and opening *h* of the cock, to the pipe *o*, *o*, leading down to the condenser; consequently, so long as the steam is acting against the under side of the piston, there will be a vacuum above it at A, to permit its ascent. So soon, however, as the piston has arrived near the top of the cylinder, the cock is turned one quarter round by depressing its handle *p* into the position below, indicated by dotted lines, when the state of the two passages through it, will be completely reversed; for now the upper part of the passage *h* will be brought opposite to the pipe *g*, while its under part will be made to coincide with the pipe *m*. The upper part of the passage *i*, will in like manner be brought down to the pipe *n*, and its other end will be addressed to *o*; consequently, the steam which now enters at *g*, will be turned upwards into the pipe *m*, and will therefore be carried to A above the piston, instead of beneath it as heretofore, and the passage *i* will form a connection between the pipe *n*, and the pipe *o* leading to the condenser; consequently in this position, a vacuum will be formed below the piston, while the steam is entering above it. The piston will therefore descend, and on coming near the bottom of the cylinder the cock must be again turned into its former position, when the piston will ascend again; thus producing an equality of force both in the up and down strokes of the piston, by this simple motion of the cock, which is brought about and produced by the motion of the main beam.

Simple and efficient as this cock may appear, it is however only applicable to steam engines of very small magnitude, on account of the necessary size of the plug when two passages are made through it, and which produces so much friction as to require more power to turn it, than can be spared from the engine. It has been ascertained by experience, that condensing steam engines require one square inch of area in the steam passage that supplies them for each horse power that the engine is required to work to; consequently, in a 16-horse engine, the openings *h* and *i* in the plug of the cock, must be each 4 inches square, or 8 inches long by 2 inches wide, which could not be obtained unless the plug of the cock was above 6 inches diameter, and 9 inches long; and even with a plug of this size, made sufficiently close to be steam tight, the force applied to the handle to turn it must be very great, particularly at the first starting of the engine, and on this account, such cocks should never be used in engines that exceed the power of 6 or 8 horses.

Mr. Matthew Murray, the well known engineer of Leeds, contrived a sliding valve or regulator, for distributing the steam in double-acting engines instead of the cock, which has given great satisfaction when applied to engines under 16 horses power, and a section of it is shewn in Fig. 6. It is fixed in the same situation with regard to the steam cylinder as the cock in Fig. 5, and has the same pipes of communication with the upper and lower parts of it, as well as with the condenser.

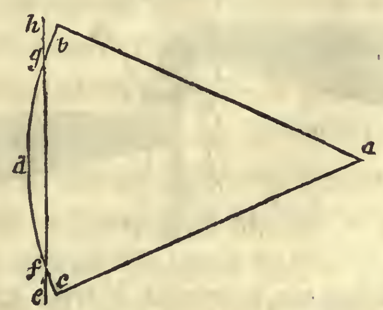
Fig. 6.



In Fig. 6, *r* is a portion of the pipe which brings the steam from the boiler, and delivers it into the small hollow chest or receptacle *s s*, so that it may always be supplied. One side of this chest *t t*, is formed by the outside of the pipes of communication to the cylinder, which, on this account are not round, but of a square or oblong form. The three pipes leading to the top and bottom of the cylinder, and to the condenser, all open through this side of the chest, as seen in section at *w u v*, thus the pipe *w* proceeds to the top of the cylinder, the central pipe *u* to the condenser, and the lower pipe *v* to the bottom of the cylinder. The face or side of the chest *s s*, through which the openings or mouths of the pipes are made, is ground very flat and true. The slider for regulating the admission of the steam is shewn at *x z*, and is like a box without a lid, made of brass or gun metal, and of such a depth as to allow ample room for the steam to pass within it, while its length from top to bottom is just sufficient to cover the ends of two of the pipes as *v* and *u*. The edges next the open part of this box or slider, are ground so flat and true that they may slide upon the ground face *t t*, in an air and steam tight manner; and in order to produce the necessary sliding motion, a truly cylindrical turned rod *y y* passes through a stuffing box, and is connected to the top of the slider within the chest. Now, since the extent of the slider is only sufficient to cover two holes, and the hole *u* is in the centre, that hole can never be uncovered; but one or other of the steam passages *w* or *v*, must always be open whenever the slider is at the top or bottom of the chest, but they cannot both be open at once, because, by the time that the upper part of the slider *x* has risen sufficiently to cover the upper hole *w*, its lower part will have risen so as to uncover the lower hole *v*; and since steam is supposed to be always entering from *r*, it is evident that it will be directed above or below the piston as the case may be. Thus, in the figure, the arrows indicate the direction in which the steam is passing, and as the slide there stands, the steam will pass directly from *r* up the pipe *w* to the top of the cylinder, while an open communication will be made between the bottom of the cylinder and the condenser, through the pipes *v* and *u*, by means of the open inside of the hollow box or slider *x x*; and if that slider was drawn to the top of the chest *s s*, then the orifices *u* and *w*, would be united to form a vacuum in the top of the cylinder, while *v* would be open for the passage of the steam to the underside of the piston. The orifice *u*, it will be seen, is never uncovered, consequently, the steam from *r* can in no case get into the condenser, which, alternately, is made to communicate with the top and the bottom of the cylinder. In this way, a small vertical reciprocating motion given to the rod *y*, by connection with the beam or some part of the moving machinery, is sufficient to produce all the necessary changes in the direction of the steam, so as to maintain the motion of the machine, with comparatively little friction; but in all large steam engines, no contrivance is found so good as the simple conical valves represented in Fig. 4.

From the nature of the double engine, and its force being continued during the ascending as well as descending motion of the piston, it will be evident that the chain connection with the beam as theretofore used, and as described at p. 14, could no longer be resorted to, for that could only be effective so long as the engine exerted a lifting force alone. The upper end of the piston rod was therefore converted into a straight rack with teeth or cogs, which worked into similar teeth formed on the circular end or horsehead of the beam; but from the great noise and friction attendant upon this construction, it was soon discarded, and gave way to the more elegant contrivance now universally adopted, under the title of *the Parallel Motion Apparatus,* and by which all the defects of the former construction were removed.

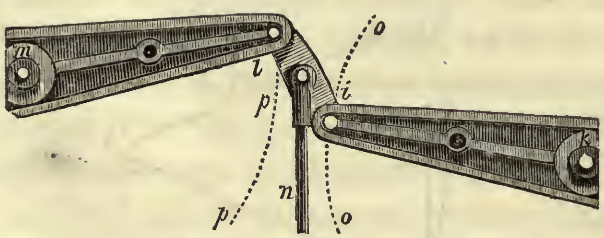
Fig. 7.



The difficulty of connecting the piston rod immediately to the end of a beam, arises from that rod being constrained to move through its stuffing box in a right lined direction, while the end of the beam performs a portion of a circle, and therefore disagrees with the motion of the piston rod. Thus if *a* Fig. 7, is the center upon which a beam turns, and *a b*, *a c* be supposed to be the central lines of the end or half of that beam, its end will describe the portion of a circle *b d c* in passing from its highest to its lowest positions, and vice versa, and if *e f g h* represent the right line in which a piston must move, it will appear that the motion of the beam and the piston rod only coincide at the two points *f* and *g*, for at the points *e* and *h* the piston rod is further removed from the center *a* than the length of the beam *a b* or *a c*, while in the central part of the stroke *d*, the length or radius of the beam is greater than the distance of the piston rod from *a*, and since every beam in moving must deviate from a right line by a quantity equal to the versed sine of the arc through which it moves, so it becomes impossible to attach a piston rod requiring a right lined movement, immediately to the end of such a beam, unless indeed teeth are used as formerly was the case.

The object of the parallel motion apparatus is to convert the circular motion of the beam, into rectilineal motion; and this may be done by intermediate pieces in several ways. Thus, for example, if *i k*, Fig. 8,

Fig. 8.



represents a beam turning on a center *k* with any given radius, and *l m* be another beam of similar radius turning on the center *m*, the two vibrating ends *i* and *l* of these beams may be united to an intermediate piece shewn between *i* and *l*, and the piston rod *n* may be attached to the middle of this intermediate piece, and will move in a right lined direction, notwithstanding the circular motion of the two beams; for these beams being of equal radius, but opposed end to end to each other, the quantity of versed sine formed by the one will always be equal to that formed by the other, but being in contrary directions they will correct each other; therefore, whenever the upper end *l* of the intermediate piece is drawn towards *m*, its lower end *i* will be drawn in an equal degree towards *k*, and thus the motion at the center where *n* is attached will be rectilineal. The parallel motion apparatus attached to engine beams is always constructed upon this principle, though it may be considerably varied in form, all that is necessary being that the piston rod should move in a straight line without deviation, notwithstanding that it may be connected with a beam or fly-wheel to which it has to communicate rotary motion.

In some cases, as when double engines are applied to pumping or to working vertical saw mills, a parallel motion is applied at each end of the beam; and when the end of the beam opposite to the steam cylinder is required to give circular impulse to a fly-wheel, to equalise the motion, and supply the deficient power when the piston is at the top and bottom of its stroke, (in which situations it is of course without power,) a crank must be used on the axis of the fly-wheel similar to the cranks used for turning foot lathes or spinning wheels, but of a strength proportionate to the power of the engine, and this crank is connected to the end of the main beam by a stiff inflexible bar of wood or metal, called *the Connecting Rod*, and which is made to move with as little friction as possible, both upon the crank and the end of the beam to which it is attached. When the fly-wheel is required to move with greater velocity than once for each ascent and descent of the piston, this is effected by applying the crank upon the shaft or arbor of a toothed-wheel, working into another with a smaller number of teeth, and fixed upon the fly-wheel shaft, from which the power of the double engine is generally conveyed to the machinery it is required to operate upon.

Such is a very general and imperfect account of the important improvements which the steam engine received under the hands of Mr. Watt;

improvements which bespeak the truly philosophical and indefatigable mind of their author, who, notwithstanding his many other avocations, and his inability to give his whole attention to the subject, was enabled to complete them in the short space of seven years.

After the steam engine had thus been perfected, Messrs. Watt and Boulton ascertained by repeated experiments that their engines would perform the same work as those in former use, with only one-fourth part of the coals that had been before consumed, and instead of charging exorbitant prices for their machines, they sold them at fair and reasonable rates, and only exacted one third part of the value of their savings during the extent of their patent, which repaid them handsomely, at the same time that it was a most beneficial arrangement for the public.

Having thus far stated the general history of the steam engine, and the uses of its several parts, up to the period of Mr. Watt's improvements, it now becomes necessary to notice some minor contrivances in this curious machine, and to state a few particulars that were passed over in silence in the general description, in order to avoid confusion. Thus, by referring again to Fig. 3, it will be seen that the water raised by the air pump *P* is not wholly permitted to run to waste, but is delivered by the spout of that pump into a small cistern *L* provided to receive it, and which is called the *Hot Water Cistern,* because the water drawn by the air pump is in a nearly boiling state, and therefore fit for replenishing the waste of the boiler without diminishing the temperature of the water contained in it. A small forcing pump *i* is therefore fixed in this cistern, having its piston rod *a* connected with the main beam in such a manner as to insure its proper motion, and the rising pipe of this pump proceeds to the boiler and keeps it at all times supplied with the necessary quantity of hot water, while the superfluous quantity only runs to waste by a spout *R* near the top of the cistern.

In order to ascertain that a proper quantity of water is admitted into the condenser by the cock *k*, and that the air pump draws off the whole of that water and any steam or air that may remain, so as to produce as perfect a vacuum as possible within the condenser, a mercurial tube called a barometer becomes necessary, and this is shown at *h* in the same figure. The barometer is made in different forms, but always consists of a wrought iron pipe or tube, opening into the upper part of the condenser, and terminating at its opposite end in a tube of glass filled with quicksilver like a common barometer, and having a scale of divisions like that instrument, as marked at the upper end of the tube *h*. The quicksilver is upheld in the tube by the pressure of the atmosphere, but when that is taken away by the production of a vacuum within the condenser, of course the quicksilver will fall in a greater or less degree, as the vacuum is more or less perfect, and thus is the internal state of the condenser rendered constantly visible. The vacuum within the condenser should at all times be maintained as perfect as possible, in order that the elastic force of the steam may exert its full energy and force to produce the motion of the piston, and since the condenser is in a state of vacuum when the engine is at work, a very minute turning of the cock *k* will produce a great difference in the quantity of water discharged into it. The importance of the injection cock is such, that in some engines for steam boats, where from the motion of the sea it has been found impossible to maintain the water of the cold water cistern at its proper height, the condensation has been wholly effected by the injected water, supplied without a cistern.

There is one more appendage to the condenser, called *the Blow Valve*, which must be noticed, as being quite necessary to starting or giving the first motion to the engine, though it afterwards becomes passive and useless. This valve is shewn at K, Fig. 3, and consists merely of a conical valve opening outwards at the end of a pipe leading to the inside of the condenser, and placed likewise in a small detached cistern of cold water. Its use is to produce the first vacuum before the engine begins to move, for since there is much more friction to overcome, while the grease in the piston packing and that of all the stuffing boxes is cold than there is afterwards, so if the steam were merely applied on one side of the piston before a vacuum had been produced upon the other, it would be next to impossible to get the machine into motion. In order therefore to start an engine the injection cock *k* of the condenser must be shut, and all the other valves opened at once, which is always provided for in the mechanism of the valves. By this, the steam will not only pass into the cylinder above the piston, but below it, and into the condenser at the same time, and this is called *Blowing Through* the Engine. It must be continued until all the parts get sufficiently hot to put them in a proper state for working, and the superfluous steam, as the parts become heated, will pass off and escape through the blow valve, which is lifted by the force of the steam, and placed under cold water in the cistern K, that it may be condensed as it escapes, instead of filling the engine house with steam. It is this blowing through that produces the very loud noise experienced in starting large engines, and it occasions a small waste of steam for a few minutes which cannot well be obviated. So soon as the engine is sufficiently heated, the side pipe valve, which permitted the steam to pass into the condenser, must be closed, and the injection cock *k* opened by turning its handle *p*, when a vacuum will be instantly formed in the condenser, and of course on the opposite side of the piston to that on which the steam is still permitted to act. The piston will therefore begin to move, and having made one or two strokes, every part of the engine will become properly heated and will continue its motion. But should this not be the case, the operation of blowing through must be repeated until it does work properly, after which the blow valve becomes useless, but is not detrimental to the operation of the condenser, because it will constantly be kept closely shut down by atmospheric pressure.

The chimney or flue of every steam engine boiler should be equipped with a damper, which is nothing more than a sliding iron plate, very commonly applied to flues or chimneys for the purpose of regulating their draught, so as to govern the intensity of the fire; for a damper closes the chimney in a greater or less degree, or shuts it up entirely, and thus permits a greater or less quantity of atmospheric air to pass through the fire, or none at all, by which it is extinguished; dampers are therefore generally under the controul of those who have the management of the fire, but in the self-regulating damper the fire controuls itself, and is made to burn with more or less violence, as it may be more or less wanted. This contrivance is therefore not only of importance in regulating the power of the steam, but in diminishing the consumption of fuel, by never permitting the fire to burn with greater violence than is necessary for the quantity of work to be performed; and all boilers should be covered with brickwork or some bad conductor of heat to prevent the condensation of steam by their exposed tops or domes.

The pipes for conveying the steam should be sufficiently capacious, and as short as possible, to prevent too much exposure of surface to the atmosphere. They should pass from the upper part of the boiler to the steam cylinder, in a direction gently inclining upwards, so that any condensed water that forms in them may run back again to the boiler, instead of getting into the cylinder, consequently every boiler should (if possible) be set or fixed lower than its steam cylinder, and in order the more effectually to prevent condensation, the steam pipes should be coated with haybands, sacking, or some bad conductor of heat, particularly if they are long or much exposed to the air; and every engine that is in daily use should have two boilers if possible, because the boiler frequently wants cleaning out and examining, and is much more liable to get out of repair than any other part of the machine. Of course, therefore, if the engine has but one boiler, it must cease to work on such occasions.

As a further preventitive of waste of steam, every steam pipe should contain what is called *A Throttle Valve,* for the purpose of regulating the velocity of the passage of the steam from the boiler to the cylinder. This valve is nothing more than a thin plate of metal, made to fit the internal bore of the steam pipe rather accurately, and fixed to a spindle passing transversely through the center of the pipe by steam-tight joints, so that it can be turned round externally by a handle or lever, and set in any direction. If the handle is fixed at right angles to the surface of the plate, then whenever the handle is directly up or down, the plate will present a thin edge towards the steam passage, and will offer little or no resistance to it; but whenever the handle is placed in the direction of the pipe, it will be quite shut and no steam can pass, so that by moving the handle one quarter round the steam pipe will be more or less closed, and the speed of the engine will be regulated accordingly with the greatest nicety. This handle is moved by the hand in engines where the work is regular, as in steam vessels, but in all cases where an engine is applied to very unequal work this would be unsafe, and it must be under the more certain controul of machinery, in which case a truly beautiful and philosophical contrivance, called *the Governor,* is resorted to. It is in fact a revolving instead of a vibrating pendulum, and consists of two heavy iron balls fixed to the lowest ends of two bars, which are attached by joints or hinges at their upper ends to an upright spindle, which revolves with due velocity by wheel work or pullies connected with any of the revolving parts of the machinery. The weight of the balls keeps them in contact with the spindle, so long as it remains stationary or moves slowly, but whenever their revolving motion increases, their centrifugal force drives them to a greater or less distance from the center in proportion to the velocity, consequently, the quicker they move, the more they will open or diverge, and this divergence is made use of by a very simple arrangement of levers and rods to produce the necessary motion of the throttle valve, which is so connected as to be quite open when the engine is not at work, or at its starting. It then receives the full quantity of steam, and moves with such velocity that the balls are soon thrown off from the spindle, by which the throttle valve will partly close it and the speed will be diminished. Hard work upon the engine will in like manner diminish its speed, and prevent the balls from separating, but the instant it is removed the additional speed of the engine will raise the balls and produce the same retardation, until by the introduction of fresh work the speed becomes so much more diminished as to permit the balls to descend again. By means of the governor an engine under very unequal work may be made to operate with very nearly the same regularity as if its load was quite equable.

It is hardly necessary to observe that the perfect action of a steam engine depends in a great measure on the inside of its cylinder being very truly bored and polished, and the apertures by which the steam enters being placed as near as possible to its top and bottom. They are never made circular but are long parallelograms, in order to give as much steam passage as possible without abstracting from the length of the cylinder; for the piston must in no case cover these holes, otherwise the passage of the steam would be stopped, while if too great a space was left above and below the piston much steam would be wasted. The steam passages are therefore very frequently formed in a protuberance above the top and below the bottom of the cylinder, instead of passing through the side of it, and in this way they are completely removed out of the way of the piston. In small engines the outside of the cylinder is cased with wood or flannel, as before mentioned, but in the larger sorts a hollow metallic and air-tight casing surrounds the whole cylinder at a short distance from it, and the space between the two is supplied with steam from the boiler by a small pipe for that purpose, by which the cylinder is kept as hot as the steam that enters it. Large engine cylinders are usually surrounded by a gallery at 3 or 4 feet from their tops, for the workmen to stand upon while packing the piston, or performing other repairs.

The piston moving within the steam cylinder, consists of two circular plates of iron attached together by screws, which at the same time serve to retain the hemp or other packing placed between their exterior edges, to make them air-tight, but with a view to save the trouble and expence of frequent packing, the piston is frequently made altogether of metal, and brass seems to answer best for this purpose, particularly when the cylinder is of cast iron, which is usually the case. The metal piston of the Rev. Dr. Cartwright has been much used for this purpose, and is found to answer very well, but that of Mr. Barton being more simple and equally effective, is most frequently resorted to. It consists of a solid ring of brass which very nearly fits the cylinder, and is first cut into the form of an equilateral triangle, by taking off three segments. The triangle so produced next, has its three points cut off so as to form three smaller triangles when the central piece is discarded, and the three segments and three small triangles are secured between plates, as in the common piston, and lastly, three spiral springs press outwards from the piston rod against the backs of the triangles, which act as wedges to press the segments against the inside of the cylinder, and as these wear by use, the points of the wedges themselves protrude, and being formed of the same metal, still make part of the piston. A piston of this description has been known to work for many years without requiring any other attention than keeping it properly greased, and for a true cylinder, it is one of the best forms that can be adopted, particularly in high pressure steam engines.

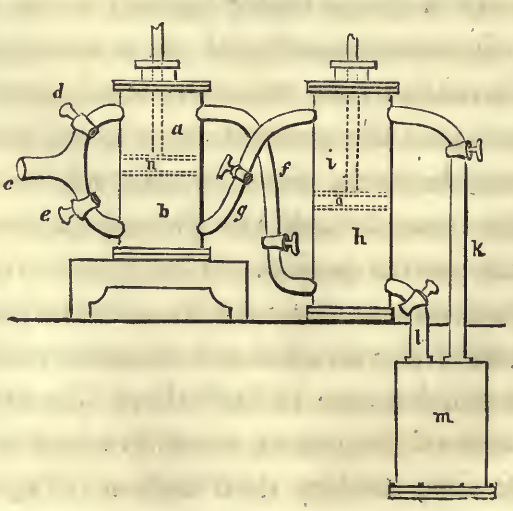
In Mr. Watt's first construction of the steam engine, the steam was permitted to act on the piston during the whole of its passage from one end of the cylinder to the other, by which the motion of the piston became accelerated and most rapid at the moment when it was required to stop. This was detrimental to the engine, not only on account of the irregularity of the motion; but from the great quantity of momentum that was necessarily generated in the piston, the heavy beam, and in fact, in all the moving parts of the machine, and which required to be destroyed between each stroke, at a great sacrifice of power. Mr. Watt however found that he could render the motion of the piston regularly progressive instead of accelerated, by gradually shutting off the steam, long before the whole motion was completed, and that with the momentum previously acquired (and which, if continued, would have produced detrimental acceleration) the elasticity of the steam before admitted would complete the stroke of the piston. This turned out to be an excessive advantage in point of expence, for instead of consuming a whole cylinder full of steam to produce each motion of the piston, it was found that half this quantity was nearly as effective, in consequence of which Mr. Watt obtained a separate patent in 1782, for this mode of applying steam. In his subsequent experiments (in which he was corroborated by Professor Robison) it appeared that one quarter of a cylinder full of steam performed 3-fifths of the work that the whole quantity would have done; so that by shutting off the steam when the cylinder was from one quarter to one half filled, very nearly the same quantity of work was done, and that with a much more equable motion than when the whole quantity was used.

This circumstance is of the greatest importance in regulating the power of an engine to variable work, since by altering the arrangement of the hand geer, the engine may be made to shut off its steam either at the end of its stroke, or any earlier period. This mode of using steam is now constantly employed, and accounts for the observation before made, that the four-way cock or slide valve are not the most perfect contrivances for distributing the steam, because in both these, the instant that a vacuum is formed on one side of the piston, steam is admitted, and continues to act on the opposite side, until by their motion the operation is reversed;

while with the separate valves shewn in Fig. 4, the steam may be shut off in any part of the stroke, while the vacuum can be maintained until the piston reaches the end of the cylinder. In large engines, where the cylinder contains several hogsheads, this produces a material saving, but in the smaller ones where the cylinder holds but a few gallons it is of less importance.

It will be obvious to any one who contemplates the nature of Mr. Watt's improvements in the steam engine that they are susceptible of many forms and applications: and indeed a Mr. Jonathan Hornblower actually obtained a patent in 1781, for a process that was highly ingenious, though probably without his knowledge it had been previously described by Dr. Falck. Mr. Hornblower's plan was to use two steam cylinders and pistons instead of one, although no additional quantity of steam was required; for the cylinders were connected by pipes, with cocks or valves, in a manner something similar to what is shewn at Fig. 9, where *ab* is the ordinary cylinder of a double engine, supplied with steam as before described by the pipe *c*, which has two cocks *d* and *e*, or any

Fig. 9.



of the contrivances before spoken of for properly directing and distributing the steam. Cocks are made use of in this figure as being the most simple, and for the same reason no preparation is made for turning them at the proper periods by machinery, but they must be conceived to be opened and shut by the hand. Pipes *f* and *g* likewise proceed from the upper and lower parts of the cylinder for the escape of the steam; but instead of leading to the condenser, as in the engines before described, they lead into the reverse parts of another steam cylinder; that is to say, the pipe *f* from the upper part of the first cylinder leads into the lower part *h* of the second one, while the pipe *g* connects the lowest part of of the first cylinder to the highest part of the second. This second steam cylinder is longer, and otherwise of larger capacity than the first, and from its upper and lower parts the two pipes *k* and *l* proceed, and terminate in the condenser *m*, as in other engines. All these several pipes have cocks or valves by which they can be opened or closed at pleasure. To work this machine, all the cocks or valves must be opened at once to blow through or fill every part of the engine with steam, after which the steam cock *d* and the cocks in the pipes *g* and *l* must be shut at the same moment, and the injection cock of the condenser opened. The steam will then enter *b*, and begins to raise the piston *n*, while that steam which was already in *a* will pass by the pipe *f* to *h*, and will consequently exert its remaining elasticity to raise the second piston *o*, above which a vacuum has been formed by connection with the condenser *m* through the pipe *k*; and as both the pistons are attached to the same end of the beam, of course the power produced by them will be exerted at the same time, and in the same direction. The pistons having gained the top of their stroke, the steam cock *e* must be shut, together with the cocks in the pipes *f* and *k*, and all the others opened, when their former action will be reversed; for now steam will enter *a* to depress the piston *n*, and that which was already in *b* will exert its elasticity and pass through the pipe *g* into *i* to depress the piston *o*, while a vacuum is formed in *h* by the opening of the pipe *l*. The pistons will therefore descend simultaneously, and by such means Mr. Hornblower expected to have derived great practical advantages, in which he was corroborated by the mathematical investigations of Dr. Robison, who estimated that this machine possessed a power over the engine of Mr. Watt, in the proportion of 853 to 833. This however proved to be one of those cases in which the theoretical investigation of a power could not be made to agree with the practical result, for after a very fair trial of this engine it was found that the friction of two pistons, and the great additional surface that was exposed to cold, more than compensated for the advantage of this mode of applying steam, at least as it was then done; although it has since been ascertained that steam of great heat and high elastic force may be worked with considerable advantage in this manner.

The engine of Mr. Hornblower was however ineffective without the condenser, close cylinder, and other improvements which had been secured to Mr. Watt by his previous patent, of which it was deemed to be a direct infringement on the trial of the case at law; consequently Mr. Hornblower was reduced to the necessity of recurring to the old plan of condensing in the large cylinder, and by this the advantages he might otherwise have obtained were quite lost, and his contrivance became useless and unavailing.

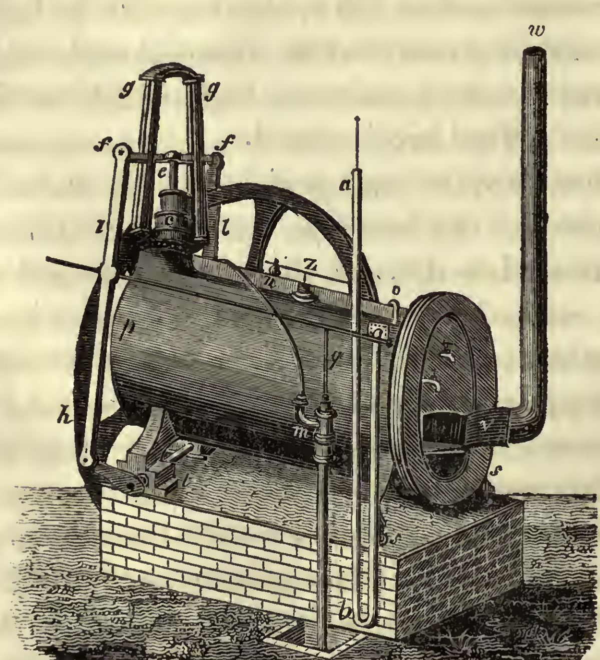
Although Mr. Watt adopted the use of steam instead of atmospheric pressure, yet in all his various constructions he confined its elastic power to a force very little exceeding that of the air, at which it may be worked with perfect safety. But the early experiments that had been tried on engines, convinced engineers that boilers might be made to withstand very considerable pressure, and if such surprising effects were produced by steam in a weak state, what might not be expected from it when its force was accumulated? Such reasoning led to the construction of what are termed *High Pressure Engines,* or those in which the steam, by additional heating and confinement is increased in its elastic power, so as greatly to exceed the pressure of the atmosphere. The operation of such an engine needs but little explanation, for since steam at 212 degrees is a balance to the atmosphere, or will appear without force in the open air, but will move a piston into a vacuous space with a power of from 14 to 15 lbs. on the square inch, so if that steam be doubled in its power or made equal to 30 lbs. on the inch, by heating it to 245 degrees, it will exert the same power against a piston moving in air, as the former steam did against a vacuum; consequently, by increasing the power of the steam, the construction of the engine may be very much simplified, for the condenser and its cistern, the air pump, the cold water pump, and all those parts that are concerned in forming the vacuum may be entirely dispensed with, and much friction saved. This is of the greatest importance in situations, where the requisite quantity of cold water for effecting condensation is procured with difficulty, and this alone, has in many instances, proved a complete barrier to the introduction of an engine where it might have proved highly useful.

The first application of strongly condensed steam to the motion of pistons appears to be that mentioned in *Leopold's Theatrum Machinarum,* 1724, and is attributed to Dr. Papin; but it does not seem to have been successfully carried into effect until applied by Mr. Richard Trevethic, of Camborne in Cornwall, who, in conjunction with a Mr. Vivian, of the same place, obtained a patent in 1802 for a form of engine which has been much used and approved on a small scale, and is very generally known by the name of *Trevethic's Engine.*

The construction of a high pressure engine is so closely allied to that of Savary, that it requires but a very small extent of inventive genius for its conversion, because the force that was described in speaking of Savary's engine as acting to depress the water, will equally well depress a piston, the power of which may be transferred to any other purpose. Mr. Trevethic's contrivance however goes much further, and embraces an entire construction of engine in which great simplicity is preserved, and considerable ingenuity displayed. His principal view in its application, as declared in his patent, was that of forming an engine so compact, portable, and independent, as to be capable of being applied to the moving of carriages on rail roads. This great object he was enabled to effect; and there cannot be a higher proof of the perfection of his plan, than its having been successfully applied, since the year 1812, to the transportation of coals from several collieries near Leeds, Wigan, and Newcastle upon Tyne.

The general external appearance of Mr. Trevethic's engine in its complete state for working in a fixed position, is shewn at Fig. 10. When

Fig. 10.



applied to loco-motive purposes the construction is the same, except that it is mounted on four wheels, one of which is the fly-wheel shewn in the Figure. The boiler of this engine is perhaps one of the best that can be conceived for the economy of fuel, though unfortunately it will not admit of great extension of size, without in some measure diminishing its security. It consists of a cast iron pipe or cylinder *p*, which is seldom more than 3 or 4 feet in diameter, and from 9 to 12 feet long, according to the size of the engine, and must be perfectly air and steam tight. The end next *p* is cast solid or close, but the other is closed by the circular plate or front *s*, the whole boiler being supported by the four legs or standards *s s t*, upon a block of brickwork or masonry built to support it. The fire is made in a wrought iron tube in the form of a syphon, the two legs of which lie horizontally within the large cylinder *p*, and this syphon is attached at its two ends to the front plate *s*; at one end it is so large as to embrace the fire door and ash pit *v*, together with the bars upon which the fire is made within the door, but its other end contracts into the iron flue or chimney pipe *w*, which must rise high enough to create sufficient draught for the fire. The large cylinder is filled with water above the surface of the syphon fire-pipe, and guage cocks are placed in the end *s*, to ascertain its contents. All heat that radiates from the fire, and even from the hot cinders below it, must therefore be communicated to the water, while the steam produced is retained in the upper part of the large cylinder. A safety valve is placed at *z*, and *a b* is a common mercurial syphon guage with a floating stick, or with a string passing over a pulley and a counterpoise weight, because the guage in this case must be 60 or 70 inches long, on account of the steam being sometimes required to press with so many pounds upon each square inch. Every part of the steam or working cylinder is hidden in this engine except its top *c*, because the whole cylinder is immersed in the hot water and steam, being fixed by a flanch at *c*, while its lower part extends nearly to the bottom of the boiler.

In this way the cylinder is most effectually kept at the same heat as the boiling water: *e* is the piston rod, which instead of being attached to a beam, carries the T piece *f f*, which moves between the guides, or steadying bars *g g*: *h* is the fly-wheel, the shaft or axle of which passes through proper brass bearings in the two legs or supports *t*, while each of its ends carries a crank (one only of which can be seen in the Figure) connected to the T piece by the two connecting rods *l l*. As the piston moves up and down, rotary motion is communicated to the fly-wheel, and from its shaft to any machinery requiring such motion; but when vertical reciprocating motion is necessary (as in pumping) it is obtained at once from the T piece. On account of the force of steam required in these machines, water is supplied to the boiler by a small forcing pump *m*, worked by a lever connected with one of the connecting rods *l*, and this water instead of passing immediately into the boiler is delivered into a pipe or receptacle *n* fixed upon it, and opening into it by the pipe *o*, so that the cold water by traversing the full length of this pipe becomes considerably heated, and does not check the production of steam.

In these engines the steam is admitted and released from the cylinder by a four-way cock such as has been described. This is placed just within the boiler at the top of the cylinder, and its lever is struck at the proper periods by tappets fixed on a small rod or plug-tree, which is attached to, and moves with the T piece; and as a throttle valve is interposed between this cock and the boiler, the speed of the piston can be regulated with the same facility and certainty as in any other engine. The difference in action between this and the condensing engine, arises from the steam being much more powerful, and in its acting against the pressure of the atmosphere instead of against a vacuum; for no condensation takes place in this machine, nor could it indeed be effected with sufficient rapidity, on account of the great additional heat of high pressure steam. As soon therefore as the steam has performed its office of operating on the piston, it is by a motion of the four-way cock permitted to escape into the open air, while the newly admitted steam is operating on the contrary side of the piston. In passing to the open air it is generally conducted through a pipe in the inside of the cold water pipe *n o*, in order that it may assist in heating the water before it enters the boiler.

From the above description, it will be seen, that the high pressure steam engine, is a much more simple, compact, and cheap machine, than the condensing one in which steam of less power is used in conjunction with a vacuum; and the only solid argument against its general introduction and use is the danger attendant on the explosion of its boiler, which when it does occur, is accompanied by the most fatal and dreadful consequences. Still however, there can be no doubt, but in time proper materials will be selected, and such modes of construction adopted as will make the use of strong steam as certain as that of less power; and since it has been most clearly proved that the increments of power in the steam are greater than those in the fuel to produce that power, so of course the expence of working such engines must be proportionably lower. When accidents have occurred to boilers, they may in almost all cases be traced, either to bad workmanship or materials, or an injudicious choice, application, union, or form of them.

High pressure boilers, if large, should always be composed of small parts, effectually and scientifically united; and materials of the greatest tenacity should be selected, such as thick plates of hammered iron or copper, which, if they fail, will merely rend or open, while cast iron from its brittleness, is dispersed in all directions by its bursting. Due attention should also be paid to placing such materials together as will expand and contract equally under equal temperatures, for the perfection and durability of a joint is greatly dependent on this circumstance. And no boiler of any description should be trusted until it has been proved by injecting cold water into it, by a forcing pump in the manner of Bramah's press, to be capable of withstanding at least twice, if not thrice the force of the steam that is proposed to be generated within it, and which may be ascertained either by loading its safety valve, or using the mercurial guage.

The high pressure engine of Trevethic was the only one that was used for a considerable time, but in 1804, a patent was obtained by Mr. Arthur Woolf, an engineer of Cornwall, for a new machine, which he did not however bring to perfection until 1810, when the improvements and alterations he had made in it were so great, that he was obliged to solicit a new patent. The perfection of this engine, as described by Mr. Woolf, does not however arise so much from any improvement in its construction, as from a new property which he states he had discovered in steam, and by which he was enabled to apply it in a new manner. His engine is in fact precisely that of Hornblower, (Fig. 9) with such slight alterations as to render it unnecessary to give a separate figure of it; and although this machine was non-effective when used with moderate steam, and especially during the continuance of Messrs. Watt and Boulton's patent, which precluded the use of their mode of condensation; yet it has since become of great importance, in the hands of Mr. Woolf. He claims a discovery, which he endeavours to establish by proof, that whatever number of pounds steam might be capable of overcoming on the square inch, so many times would it expand, and yet remain equal to atmospheric pressure, provided its original temperature was maintained. In other words, if steam is strong enough to raise the mercurial guage of a boiler 6 inches, or to open an inch safety valve loaded with 6lbs. weight, against the pressure of the atmosphere; that same steam may be admitted into another vessel, six times as large as the first, and still it will be equal to steam of one atmosphere (or 212 degrees) so long as its first heat is preserved. Taking it for granted that this law holds good in steam, its beneficial action in a double cylinder engine, will be immediately apparent, and such is *The Steam Engine of Mr. Woolf.* He proposed using steam of about 40 lbs. power on the inch, and this was to be admitted by the pipe *c* Fig. 9, into the cylinder *a b* precisely as before described in speaking of Hornblower's engine, which was only altered for his purpose by making the second cylinder much larger than the first. For if steam of 40 lbs. was capable of extending its magnitude forty times, and yet remained equal to the atmosphere, of course, if the second cylinder had forty times the capacity of the first, the steam when discharged into it, would still be atmospheric steam. A condensing engine however requires steam of about four pounds more than atmospheric power on the inch; consequently, if the second cylinder be not quite forty times the size of the first the entire object will be gained; for the steam on its first admission will act with a power of 40 lbs. upon the first piston *n* to raise it, and is afterwards admitted to act above the second piston *o* to depress it in into the vacuum formed in *h* by the ordinary process of condensation; while at the same time a new quantity of 40 lbs. steam, has been let in above the first piston *n* to assist in the operation. This engine therefore consists of a high pressure and a condensing engine so united, as to act with one common quantity of steam, which is made to co-operate on two pistons always moving in the same direction at the same time, and thus uniting their power.

The beam, fly-wheel, hand geer, and various other parts of an engine as before described are applied in this, as in all other steam engines, consequently, nothing need be said upon them. But Mr. Woolf was too well acquainted with the nature of strong steam to attempt its production in any of the large boilers that are commonly used for this purpose, and he therefore invented a boiler peculiar to himself, and which formed part of his patent invention. In this, which is altogether made of cast iron, he very properly uses forms which admit of the greatest strength in their construction, while none of the parts individually expose much surface to the action of the steam. His boiler consists of several strong tubes of about 10 inches in diameter and the entire length of the fire place. They are placed parallel to each other in a gently sloping direction, at a small distance above the fire, and their upper ends all open into the lower side of a large cylinder set in brickwork above them in such manner that its lower part is also exposed to the fire. The steam as it is generated in the lower tubes rises up into the large cylinder through the water contained in it, and is retained above the water until required by the engine.

The method Mr. Woolf took to insure the due temperature of the steam in his cylinders was that of making their jackets or casings the passages by which steam was delivered into them, for it passed from the boiler into the casings, and from thence to the interior of the cylinders, which were thus kept at all times, as hot as the steam that had to enter them. On the whole therefore it will be seen that no pains have been spared by its ingenious projector to make this engine as perfect and as safe as is consistent with the nature of high pressure steam. The accordance stated by Mr. Woolf to have been discovered by him between the exact power of steam and its expansion, was considered by all, as of an extraordinary nature; but more recent and accurate experiments that have been tried, show that it does not exist to any thing like the extent at first imagined: consequently, the disparity in size between the two cylinders is found to be much less than was at first hoped and expected. The large cylinder is however made from 5 to 8 times the size of the smaller one, and in this proportion the engine of Woolf appears to be the most powerful, with the least consumption of coal of any that has yet been laid before the public. It has been chiefly used in the mining districts of Cornwall, where perhaps a better opportunity of examining its merits has occurred than could be met with in any other place, not only from the great depth of the mines, and the nature of engines being there so well understood and so often put in competition with each other, but from the intrepid manner in which high steam is there regarded; for had it been liable to accidents, they must have frequently occurred.

Notwithstanding the arguments that may be adduced in favour of high pressure steam engines, still in the form in which they have been hitherto constructed, they should in no case be resorted to, where the low pressure or condensing engine can be substituted in their stead, especially for maritime purposes. The saving of a small quantity of fuel may be an object of great importance to the manufacturer, but is by no means to be put into competition with the lives of the passengers or crew who may be constantly surrounding the machine, and who therefore cannot ever be exempt from some risk of danger. It is true that accidents do not very frequently occur; and it may be urged that the low pressure boiler being constructed in a weaker manner, is more liable to accidents from inattention to the fire, than that which is formed with a direct view to strength. But admitting that the one is as secure as the other, still the effect of the explosion is sufficient to turn the scale of preference, for while the bursting of a low pressure boiler hardly ever extends its influence beyond the limits of the room which contains it; that of the high pressure spreads devastation around it on all sides; of which, unfortunately there are but too many instances on record. It is however daily gaining ground, and with further and better experience, and by new modes of construction, may at length become safe and common. In America the use of high pressure steam is much more common than it has yet become in England, and there it is by no means a rare occurrence to hear of the use of steam equal to 100 lbs. or more, on the square inch.

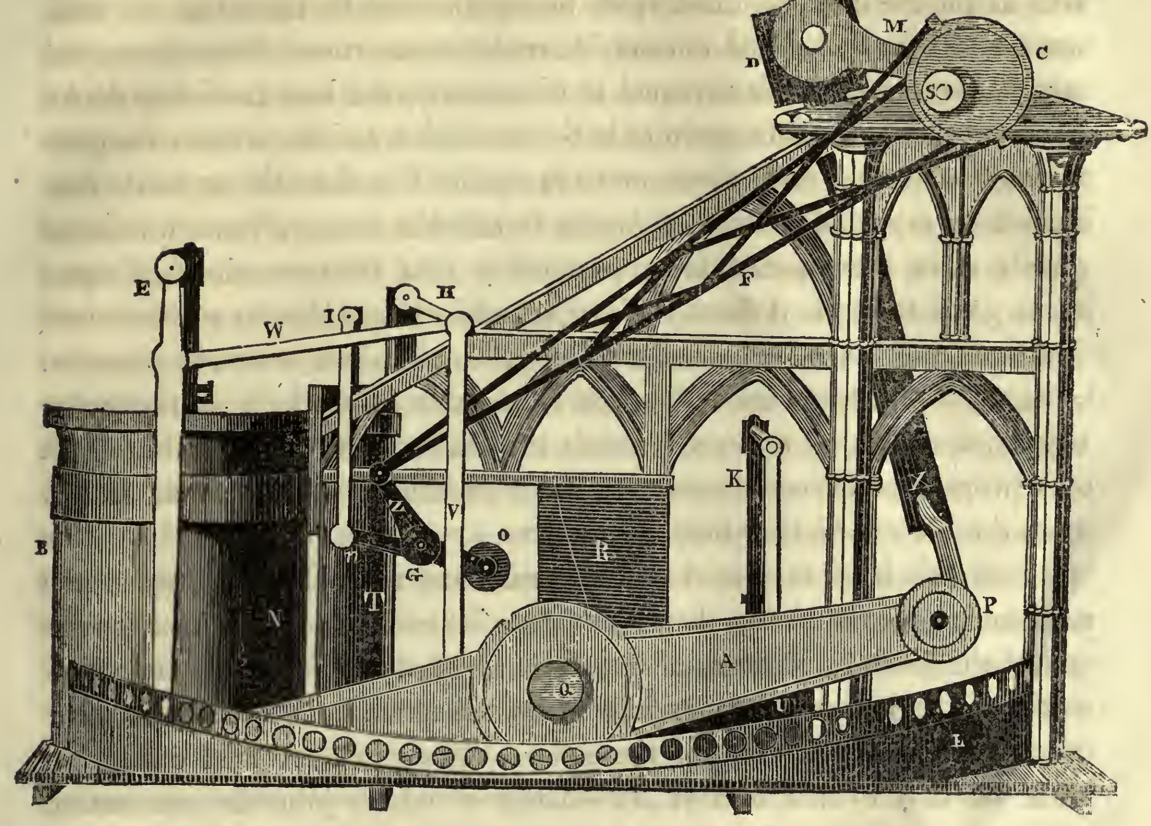
Before dismissing the subject of the steam engine, it will be necessary to offer a few remarks on the attempts that have been made to improve it, by dismissing the beam, and obtained a circular or rotory motion, immediately from the action of the steam without the intervention of a crank.

Such a construction, is unquestionably a great desideratum, especially for nautical purposes; because the inertia of the heavy beam and piston, as well as the friction produced by them and their appendages must be overcome at every stroke, and not only abstract greatly from the power of the machine, but add to the expence of its construction, and the room that it occupies. All the attempts that have hitherto been made to accomplish this desirable end, have however so far proved ineffectual; at least, they have been attended with such practical difficulties, as to have precluded their general introduction into practice; for the friction attendant upon them, as well as the difficulty of maintaining the packing in a steam-tight condition, has proved so great, as to more than overbalance every expected advantage. Indeed, the difficulties attendant upon this construction of engine, are such, as to leave little hope of its ever being brought to that state of perfection, which may render it superior, or even equal to the engine in its alternating form.

With a view to render the condensing steam engine as strong and compact as possible, and thereby to fit it more completely for maritime use, the disposition of many of its parts as before described, may be transposed, and this has been very effectually and completely done by Messrs. Maudslay and Co. in some very excellent engines of about 40 horse power each, which they constructed for some post office and other government packets. Their form of engine is shown at Fig. 11.

After the description already given of this kind of steam engine, it will merely be necessary in this place to state the names of the several parts which are as follows. B N is the steam cylinder firmly bolted down to some of the main transverse beams of the vessel. This cylinder has a close top, the engine being on the double acting principle, and it is made of larger diameter in proportion to its height than in those engines that are used on shore, in order to obtain great power in a compact form, by not extending the stroke of the piston to too great a length. T is a tube

Fig. 11.



or side pipe, which receives the steam from the boiler, (not shown in the figure) and at the same time contains a peculiar sliding valve, on the principle of Fig. 6, by which the steam is conveyed alternately above and below the piston. The piston rod works through a stuffing box and terminates at the top in a T piece, from each extremity of which, as E, stiff bars or connecting rods descend, and are attached to one end of the main beam Q A P placed near the bottom of the machine for the sake of strength and to save room. This beam turns or vibrates on the center Q, which is strongly supported, and the beam is composed of two cast iron plates of similar form, one of which is placed on each side of the machine. The extreme end P of this double beam is united by means of the connecting rod X D, with the crank M, which turns round the main central axis S, performing a circle equal in diameter to the length of the stroke of the piston. To this main axis S one of the paddle wheels for propelling the vessel is attached, and the paddle wheel on the opposite side is fixed upon a similar axis belonging to another engine, because in large vessels it is always customary to employ two steam engines of equal power, and to connect them each to a paddle wheel, but in such manner that their effect may be concentrated on the main shaft or not, at pleasure. C is an eccentric wheel fixed upon the main shaft S for working the steam valves, which it does through the medium of the long but light open worked or braced connecting rod F, which is united to an arm Z upon the lever *n* G O, which turns upon a center or fulcrum at G. The end *n* of this lever is joined by the connecting rod *n* I to the top of the rod that works the slide valve, and O is a balance weight at the opposite end of the lever to compensate for the weight of the sliding piece, which covers the steam openings, and by means of which nothing remains to be overcome but the friction of the slider. The short lever H connected with the two rods V and W, (the latter of which joins the connecting rod E) form a parallel motion apparatus for insuring the truly vertical motion of the piston rod. In ship engines an open condensing cistern is inadmissible on account of the motion of the vessel, and the condenser is not therefore set in a cistern, but is made of a much greater capacity than usual, but in the figure it is completely hidden by the beam. U is the lower part of the air pump and K its piston rod, worked by a connecting rod rising between the cheeks of the beam, but the air pump is chiefly hidden by the beam and the iron fence work L, placed to keep persons from injury by the working parts. R is the hot water cistern which receives the condensed water from the close top of the air pump U, and from this vessel it is conducted into the boiler, which is upon the Trevethic principle, that is to say, no brickwork is used to set it, but it is made of thick sheet iron, or more frequently of thick copper, and the fire place is a square tube passing in a circuitous direction through the water, in order the more effectually to distribute the heat before the smoke reaches the flue. The boilers of steam vessels are, moreover, not made of the waggon or cylindrical shape, before described, as applying to engines to be used on land, but they generally fill up the whole of that part of the vessel that is appropriated to them from side to side and from deck to deck, and as the fire place and flue is surrounded on every side, except at its door, by water, which in its hottest state is never much above the boiling point, this affords one of the most effectual safeguards against the heat of the fire being communicated to the timber of the vessel, which cannot be too securely guarded against. Ship boilers, on account of their requisite dimensions, are generally made in two or three separate parts, which fit together by flat sides, and therefore waste no room, but the flue or chimney pipes runs in common through them all, and the parts are securely joined after they are set in their places. This mode of construction is very convenient and affords great facility in getting the boiler into its place after the ship is built; and it is economical, because if one part of the boiler should be burnt out, or destroyed before another, that part can be renewed without disturbing the rest. It moreover possesses the important advantage of keeping the water in separate compartments, so that it cannot roll in a great body from one side to the other, and thereby destroy the ballast of the vessel, nor does it admit of any great portion of the metal of the boiler becoming uncovered with water, and thereby becoming more hot than would be convenient.

One of the greatest inconveniences attending the use of large boilers at sea is, that they evaporate and waste too much water, to permit of their being supplied with fresh water, and, consequently, their supply must be obtained from the sea, and as sea water deposits its salt, which crystallizes upon the boiler, and particularly in the hottest places, as the evaporation proceeds, this deposition of salt prevents the transmission of heat from the fire to the water, and cannot be too much guarded against. A certain loss of fuel must on this account be submitted to. The most effectual remedy that has been found, is a frequent change of the water, by letting a much greater quantity pass into the boiler than is necessary to supply the waste of evaporation, and by occasionally letting off the superfluous quantity by a cock or valve constructed for that purpose. By care and judicious management of this kind, the water may be prevented from ever becoming fully saturated with salt; for as hot water holds more salt in solution than that which is cold, a much larger portion of salt will pass off with the heated water, than will enter with that which is in a cold or tepid state. If steam engines could be constructed to work the same quantity of water over and over again without waste, it would be a most desirable improvement; and how far this has been effected will be shewn in a future chapter, which I shall devote to an account of the most recent improvements that have been made in these important machines.

CHAPTER II.

STEAM SHIPS AND VESSELS.

THE ships and vessels proper in Steam Navigation, will admit of a still greater variety than sailing vessels; and, although none have as yet been constructed of a greater tonnage than 1,000 tons, there is no good reason why they may not be made twice as large, or of as much tonnage as the largest ship in the Navy; for, although there may be a limit to the size of the boiler, shaft, and other parts of the machinery, there can be none to the number, and there can be no objection to two sets, if the ship is too large for one: the construction and model of a steam ship must, however, be essentially different from that of a sailing one; and I am naturally led to this subject, before I touch upon the main object of this treatise. Steam ships intended for war, may be divided into four classes; first, those intended for cruizing; secondly, auxiliaries to ships of the line and frigates; thirdly, for protection to the coast; and, fourthly, for despatches and convoys. The first class should be made to combine the qualities of a sailing vessel, with those of a steam vessel; but, as sailing must in all steam vessels be considered the secondary quality, the construction, or the proportions of a ship of this nature, must partake more of the form necessary to a vessel moved by this machinery than to one dependent only on her sails. The length and breadth ought to be greater in proportion to the depth, and a vessel of this nature must be also flatter in the floor, than is usual in sailing vessels; while, in order that the paddle wheels may be secure from the action of the waves, the projection in the sides, called the sponcing, must be carried up in a manner which will be apprehended by attending to the following plan,

Fig. 13.

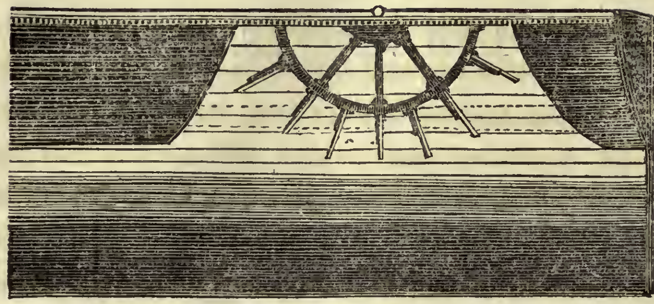
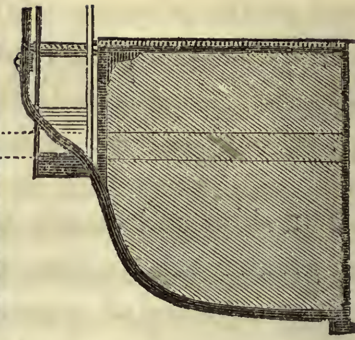


Fig. 14.



so as to make that portion as solid as any other part of the ship. This is to be done by carrying timbers, curved according to the form necessary for admitting the water to the paddles, from the floor of the ship to the very outermost projection, as well as within the paddles, deviating very little from what would be the regular form of a sailing vessel, which may be done, indeed so, that at a short distance, the difference will be imperceptible. It will be useful here to give the proportions of one vessel built on this principle, which is known to have possessed the best qualities, both under the action of the engine, and that of sails, and which has, without having received any material damage, continued for two winters, to ply in the Irish Channel; a sea, open, (as is well known) to all the swell of the Atlantic. The dimensions of this ship, called the Town of Drogheda, are as follows.

Length of Keel - - - - - - - -	116	Feet.
Length on Deck - - - - - - - -	130	do.
Breadth between the Paddles - - - -	23	do.
Extreme Breadth - - - - - -	$27\frac{1}{2}$	do.
Depth of the Hold - - - - - -	13	do.
Draft of Water, with Engine & Coals, but not Cargo	$9\frac{1}{2}$	do.

This vessel is about 250 Tons, and has two engines of 55 horse power, each on the principle of Boulton and Watt; which, together with the boiler, occupies nearly one-half of the tonnage. There is, consequently, little room left for fuel, stores and provisions; but this can be remedied, by substituting the high pressure engine and boiler, on Mr. Gurney's plan, which has been already described, and which will occupy but one fourth, instead of one-half of the space. The proportions of this vessel, may be increased to the size of the largest ship in the navy; in which case it will be necessary only to add to the number, instead of the size of the engines. The stem and fore-foot of a steam ship of this kind, should be narrow, and with about an inch in the foot more rake than in sailing vessels; but the keel ought to be equally deep: the object of the first being to give the rudder more command, and of the second, to prevent rolling and falling to leeward, when cruizing under sail. The bow above water ought to be full, forming with the stem nearly a horizontal semicircle, and with the forefoot, a vertical one, as represented in these diagrams,

FIG. 15.

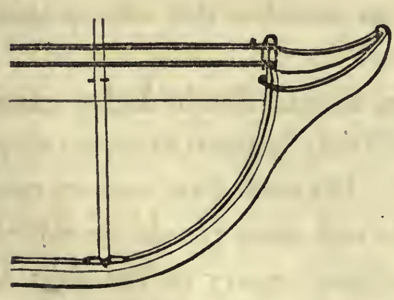
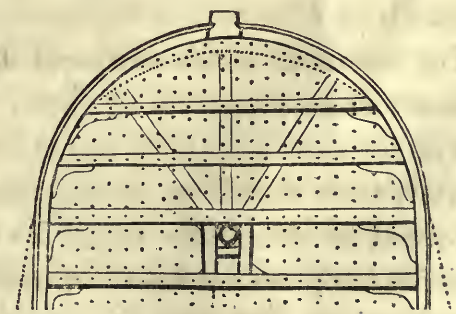


FIG. 16.



which proportions have been found best both for safety and velocity. The floor ought to be flat, both for the sake of buoyancy and convenience;

because a vessel of this construction will displace less water, or at least, the water which she displaces, will be nearer the surface, whence she will require less force to impel her through it. The run ought to be very clean, and she ought to draw rather most water abaft. The rudder should in its proportions, be one-fourth, or, according to the length and size of the vessel, one-half broader than in sailing vessels; the direction of the vessel being while under the power of steam, often entirely dependent on the helm; the sternpost and rudder ought also both to be secured in the strongest manner possible.

As the vessels which I am now describing, are intended to be kept under sail while cruizing, it will not be proper to deviate more than necessary from the usual methods of fastening and strengthening the frame; but that part allotted to the engine and the sides, where the shafts protrude, should be particularly supported by sleepers and knees, so as to prevent any tremulous motion, which is apt to be occasioned both by the engines and paddles, and also to counteract the effect of the waves on that exposed part. In constructing the paddles, the proportions depend on the power of the engines, the length of the crank, the height above water, &c.; but in all cases, it will be adviseable to have them rather within that proportion in breadth, so as to diminish as much as possible the overhanging weight.

The bulwarks which surround the outside, should also be light, unless guns are to be supported by them, which will only happen in steam ships of a larger class than have as yet been built. On each bow and on each quarter, there should be strong timber heads and cross pieces, to which, tow-ropes or shore-fasts might be taken, without injury to the ship by straining her; and the davits for quarter and stern-boats should be well supported and secured. The following parts of a vessel of this nature should be increased in actual strength by one-fourth: viz. the keel, stem, apron, or inner stem, futtocks, floor timbers, dead wood, stern post, transom, inner post, frame timbers, and filling timbers abreast of the engine; as should also, the wales, the rudder, and the rudder fastenings.

The best wood for building steam vessels, is the Tyroleze and Alpine Larch, which has a decided superiority on account of its buoyancy and durability.

MASTS, YARDS AND RIGGING.

It is now necessary to describe how a steam ship ought to be masted and rigged; for although sailing is a secondary consideration, it is one of much importance, since it has been before stated, that in all ordinary cases of cruizing, the ship will be kept under sail. The proportions which the masts should have in point of weight and dimensions, and the positions in the ship, comprise the two main considerations.

All steam vessels intended to cruize at sea, should have three, or, if above the size of a frigate, four masts. Each of these should be in the proportion of a Schooner's lower mast, and must vary as these do, according to the length, breadth, and depth of the vessel, and also according to the climate for which the vessel is intended. It is therefore of little use to attempt to fix any exact rule of proportion; the nearest approximation is by deducting one-third from the length of each mast, as it should be in a vessel entirely for sailing, increasing the thickness at the deck one inch in fifteen, and decreasing its thickness one inch in fifteen at the head: whence the main-mast of a steam ship of 1,000 tons, (the average size of a forty-gun frigate,) would be 62 feet instead of 93, and 30 inches diameter at the deck instead of 28, &c. The bowsprit also is subject to the same reduction. The mast heads should not be burthened with tops, which hold wind, and materially impede the velocity, and which, though necessary for the support of the topmasts of a sailing ship, are not required to sustain those of a steam vessel, the topmasts of which should be light, and always struck before a gale, at the time the topgallant masts of a frigate would be, and when propelling against the wind. Cross trees, (which have not the disadvantage of holding much wind) are sufficient to support topmasts suitable to a steam ship; and should therefore be always fitted instead of tops, while these also can be made to unship, and be taken down on deck at pleasure.

The topmast of a steam vessel must be regulated as to its length, by the length of the lower mast above board, and its heel when struck should be nearly at the deck; it should indeed be of the greatest possible length that can be conveniently got upon deck, and its diameter should be similar or proportional to that of a schooner's topmast. There should be nothing above the topmast; because the advantage derived from light sails in a steam vessel, is so trivial, as not to atone for the weight which is necessary to support them. If, for example, such a vessel is before the wind, she will go faster by the aid of her machinery than from the power of a light breeze; while, if the wind is on the beam, their pressure and effect in heeling the ship, are more disadvantageous than any velocity which can be gained by them. If, again, the wind is before the beam, they are decidedly disadvantageous, as the gear belonging to them will impede the velocity much more than the effect of additional canvas will add to that. A mast, any higher than a topmast, is therefore disadvantageous, under all circumstances, besides being an additional expence: and in the mizen mast in particular, no topmast is necessary or useful under any view.

The position of the mast is next to be considered. It must be kept constantly in mind, that masts and sails are secondary in a steam ship, and therefore their positions as well as their proportions must be regarded chiefly as auxiliaries to the machinery or impelling power. It is in all cases a mistake to suppose, that because the ship is long, the foremast should be placed proportionally further aft, and the mizen-mast further forward; the reverse, even in sailing vessels is the fact, because a long vessel takes more time, and requires more room to tack and to wear, and indeed to perform every evolution. It ought to be evident indeed, that the further from the extremities of a vessel the masts are placed, so is their power of acting on the hull diminished; since this may be viewed as if they were so many weights acted on by levers, the ends of which are the stem and stern. But when it is considered that steam vessels are still longer in proportion than sailing vessels, and that the masts should be placed so as to assist the steerage of the vessel, there cannot be a doubt but they ought to be placed as near the extremes as they can possibly be secured; and the rule for placing them should be, that the step of the fore-mast should be on the *fore-foot*, and that of the mizen-mast should plumb with the heel. If the ship is long in proportion, or large in tonnage, she should have two intermediate masts; but if the usual dimensions, or under the size of a 36-gun frigate, one intermediate mast in the centre of the ship, will be sufficient. In this case, this additional mast should bear the same proportions as a similar one would do in a three-masted schooner, as far as regards its shape and thickness; but it should be one-fourth shorter than it would be if it were rigged solely for sailing, in a ship of similar tonnage. The same directions respecting the top-masts, which have been already given, may be followed. Where two intermediate masts are required, they should be equi-distant from each other, dividing the space between the fore and mizen-masts into equal parts; the foremast of these being called the first, and the after the second main-mast. The reasons for these arrangements, will be given in the chapter of Naval Tactics, but the yards suitable must now be described.

The yards suitable to a steam ship, should be also small in proportion to those of a schooner. They should consist of a fore and main-yard, with a fore and main topsail yard; there is of course no necessity for any yard on the mizen-mast, there being no top-mast fitted to it. There should also be two spare topsail yards, one-third shorter, but of the same thickness, the use of which will be pointed out hereafter. Every mast should be fitted with a gaff for its large fore and aft sail, an done for the storm sails. The proportions however of all these yards and gaffs, must be subject to much variation in their dimensions, according to the relative length and breadth of the vessel. The same may be said of the mizen or driver boom. The usual dimensions for a main-yard, are 8-9ths. of the length of the main-mast, and for a fore-yard 7-8ths. of the length of the main-yard; for a main topsail yard 5-7ths. of the length of the main-yard; for a fore topsail yard 7-9ths. of the length of the main topsail yard. The centre diameter of the lower yards should be one quarter of an inch for every foot of length.

The sails of a steam ship, should consist of a fore and aft sail to each mast, set upon a gaff; these being intended for the usual wants of the vessel, while there should also be a trysail to each mast, to be set in storms. If rigged with three masts, she should have two topsails; if with four masts, three; no topsail on the mizen-mast being necessary in any case. She should also have two storm topsails fitted to the short topsail yards, and made of stout canvas; the use of these being for the purpose of scudding, and for *lying-to* in a storm when the sea is heavy. A square sail should be fitted for the fore and main-yards; but that should always be set flying, or, in other words, from the deck. Lower and topmast studding sails may be also used at times with advantage; and there should also be a staysail to each mast, together with a jib and flying jib, as in a sailing ship; the use of which will be fully explained hereafter.

OF THE RIGGING PECULIAR TO A STEAM SHIP.

In rigging a steam ship, it is of much importance that the ropes necessary to support the masts and yards, should be so contrived as to hold as little wind as possible, that the velocity of the vessel when impelled against it may not be impeded; and as it is plain that when one rope, and two, of equal tenacity, are opposed vertically to the wind, as shrouds, the former, though much thicker than either of the other two, will hold less wind, it is recommended that in all cases, the shrouds which support the masts and bowsprit should be of the same thickness or diameter, as they would be for the masts of a sailing ship of the same tonnage, the mast of which would be one-third higher. The number of shrouds, should at the same time, be diminished by one-half. The fore and after shroud of each mast should also be fitted on the plan of a pendant, which would admit of being removed at pleasure. The stays might be a little reduced: the blocks at the mast heads necessary for the running rigging, should be fitted with iron straps and hooks, or made to lash in their places, so that they could be sent down when not required for use; while the dimensions of these must also be regulated by the size of the materials they have to support. The bowsprit should be well secured, and as the rigging attached to it is below the level of the upper part of the hull, there is no objection, on the score of impeding velocity, to the size or number of the ropes which support it; and as it will, in propelling against the action of the waves, be often severely tried, the bobstays should be double, and also considerably stronger than those required for a sailing vessel of equal tonnage; the bowsprit should be double-gammoned, and, on the upper side, well supported by an oak fish. The jib-boom should also be strongly rigged, with double guys leading to the forecastle, and fitted so as to be quickly and easily sent on deck. All the blocks necessary for the running rigging, should be wide enough to admit the ropes very easily, for they should always be unrove when propelling against the wind. The lower yards should hang constantly by the geer which hoists and lowers the yard when wanted; which, in large ships can be done, as well as every other heavy work, by the aid of the steam engine. The topmast rigging should all lead on deck, and be fitted to shorten and set up according to the position of the top-mast for the time; that is, in the different cases when it is entirely up or reefed. When the top-mast is lowered on deck, the rigging ought also to be sent down; the cross-trees being constructed so, that the rigging can be unshipped, by having lock notches, instead of holes to admit the shrouds. It will be found both a safe and convenient method, to hang both lower yards and top-masts by double chains, reeving through check blocks, the former below, and the latter above the cross trees. To the after or hoisting end of this chain, the purchase for swaying up, whether by manual labour or by machinery, is to be attached; while it will be more speedily lowered by hand when necessary. The braces ought to lead each way, and be single or double according to the size of the ship, in order that the yards may be kept steady; and they also will be sent down with the yards; the methods of performing which, will be treated of in their places.

The construction of steam vessels, as auxiliaries to ships of the line and frigates, is the next subject to be discussed.

There can be no doubt, that in a future war, a fleet of men of war, and indeed a small squadron, will scarcely be effective, without a considerable if not an equal number of steam vessels, to act under various circumstances; and, among other things, their province will be to tow, or increase the velocity of the ships, in calms or light winds, and particularly in action. As such a vessel can always be taken in tow, under other circumstances, her masts or sailing qualities, are of much less importance than in the case of a cruizer. The weight and solidity of a vessel of this kind, will always be an advantage, inasmuch, as it will add to the momentum; or, when once set in motion, the *vis-inertiæ* will be more able to overcome the inequalities of resistance, occasioned by the sea acting on both ships.

Vessels constructed for these services, should therefore be made as strong as wood and iron can make them ; indeed, they may be so fortified, as to resist shot at distances where it would take complete effect in the sides of her consort; at any rate, the part which contains the machinery, should be fortified in that manner. The dimensions of this kind of ship, should be nearly those of the vessel already mentioned, except that she should have two feet more depth of hold, to enable her boilers, and other parts of the machinery, to be placed under the water line; which, with the exception of the shaft and crank, may be easily done. There are inventions indeed, which, if they succeed, will remedy that defect also, and, thereby render the auxiliary steam vessel, not only perfectly secure from injury during a general action, but fully able both to assist in keeping her consort in her station, and in annoying her opponent. A more minute detail of the construction of this kind of ship, must be withheld, for obvious reasons. As to the masts and rigging, being objects so comparatively small, it is only requisite to say, that they should be constructed so as to lower entirely down, when the vessel is wanted for service. The engine will of course be powerful in proportion to the size of the vessel, which will be dependent on her consort for fuel, and she will either be always towing, or in tow of her consort: the tactics peculiar to which service, will be fully entered into in the proper place.

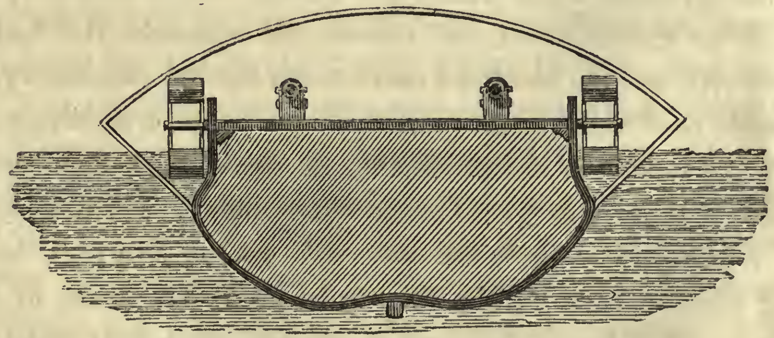
The next class of steam vessels to be described, is one of the highest importance ; namely, that which must be employed in the defence of the coast. The dimensions of this class of vessels will vary according to the nature of the part of the coast to which they are attached. Some will be made to sustain the sea in the most boisterous weather; and these will differ nothing in the construction of the hull, from cruizing vessels, the only one requisite, being in the masts, sails and rigging: and as the quantity of fuel is of less importance, the engines may be made more powerful, and secured from the effects of shot at a distance of six hundred yards. The Downs will no doubt be the principal rendezvous of the largest class. Those which are to rendezvous in Dover Pier and the several dry harbours along the coast, ought all to be of a light draft of water; but they may be of various sizes, and their engines must either be protected, or the boilers, at least, must be placed below the water-line, as they will probably have to do the work of a battery in defending the coast. It is a mistaken idea to suppose, that the steam ships now in use could be made available for the defence of the coast: the fact is, that neither the vessels themselves, nor the machinery, are at all suitable, except for carrying troops. In the manner in which the boilers are placed, the engineer who attends the engine, and the stokers who attend the fire, would be unable to remain in their stations; knowing that the first shot which struck the boiler, which, as it is now placed, could scarcely be missed in action, would occasion their being scalded to death. In the event of hostilities, therefore, the whole system must undergo a perfect change, to become effective. The following wood-cuts are intended as a perspective view, and a section of one method of improvement, which has been found by experiment to be effective : but it is not held out as the only, or even as the best which can be resorted to, while a minute description is witheld for obvious reasons.

Perspective View of a Steam Vessel fortified against Shot.

Fig. 17.

A Section of a Steam Vessel fortified against Shot.

Fig. 18.



The masts, rigging, and sails of these vessels, need not be noticed, as they will be a very secondary consideration, and have been already sufficiently described; but it may be added, that the best plan is to have them fitted to lower down by the stays, as they will then be able to ride longer at anchor on the coast where most wanted, and also much diminish the expence, both in the original fit-out, and in the wear and tear.

It now remains to describe the construction of steam vessels to be employed in the protection of the trade and convoys, which is also a service of much importance. These vessels should be made to combine the qualities of a sailing vessel, and those of a steam vessel; and, indeed, would differ very little in the appearance of the hull from a sloop of war. A model of a vessel suitable for this service, and conveying dispatches, is in the possession of the Honourable East India Company, and is nearly the mould of a New York and Liverpool Packet, while it differs so little from the Town of Drogheda, already described, that it is unnecessary to recapitulate the minutiæ. These vessels will sail faster under sail only, than most of the convoy of common merchant ships; and if they accompany a convoy of Indiamen, they can be kept in tow by one of the fastest sailing ships, while she will be at hand to tow the Indiaman in her turn, when calm, or in light winds. The engines should be more powerful, on purpose to tow up those ships which get astern and to leeward; and as they will look to the ships of the convoy to replenish the fuel when required, they will be able to afford more room for the machinery.

Steam vessels used entirely for mercantile purposes, will have a greater depth of hold in proportion to the dimensions already given, in order that they may carry a greater cargo; these, when loaded, will displace more water, and, consequently their velocity will not be so great, but their inertiæ being greater, they will be able to sustain the effects of the sea better than a vessel of less draught of water, and keep their head against a squall, when those built entirely for sailing, cannot. Of these, the Thames of 500 Tons, which trades regularly between London and Dublin, both summer and winter, is one of the best specimens; those that are built for the navigation of rivers, for passengers and goods, must, both in size and draught of water, be built according to the nature of the river or water in which they are to be employed, and a minute description of these would be needless. Those intended for ferries, should be short in proportion to their breadth and depth, in order that they may take less room in performing their evolutions, and be more under command of the helm. Masts, sails, and rigging, may be entirely dispensed with in a vessel of this description.

Having described the construction and equipment of steam ships and vessels, as regards their navigation, it remains to treat on the subject of their armament, which has occupied the attention of naval officers in no moderate degree, and on which a great diversity of opinion exists. That steam vessels will be armed in many ways, there can be no doubt; for the guns, as well as the vessel, must be suited to the service on which she is to be employed, and as well as to her size and construction. But, as it is most probable, that they will have ships of much greater force in weight of metal to contend with in the first instance, it follows, that they must be armed to avert that disadvantage. In the class of vessels which has been first described, viz. Cruizers, it will be indispensible to have one long gun, a 32 or 42-pounder to traverse in midships, or in such a situation as that it can be fired on either side or over the bow. To a vessel above 200 tons, two of the same description may be mounted, and they should be secured, when not in use, near the centre of the ship, fitted on slides that should be of the most approved plan, and also provided with sights; and there should also be marks on the carriage, and on the deck, to denote its actual elevation, and the number of degrees in azimuth, which they point from the ship's head; while all their motions should be directed by screws. The rest of the armament should consist of carronades of the same calibre, their number being according to the tonnage and capacity of the vessel; there should be no guns mounted either far-forward, or far-aft, nor should they be placed on the projections, (if there are any) but kept as near the centre of the ship as possible, and only run into their places when required. If the ship is of a large class, there can be no doubt but she will be armed very much in the same manner as a large frigate now is; and it is extremely probable, that before long, vessels of this nature will be constructed with two decks.

All small vessels must be armed with one long gun; but if their sides are fortified against shot at a particular distance, they may be armed with the same kind of guns which are now in use; the advantages of the various modes of armament will be explained in the proper place. Again, it is highly probable, that steam will be hereafter used, to a certain extent at least, in place of gunpowder, as its elastic force is fully ascertained to be, when at a pressure of 50 to 70 pounds to the inch, much greater than that of gunpowder, while it is also capable of throwing a shot with much greater advantage; besides which, the gun can be fired much quicker than it is possible to load a gun in the common way. In this case, and in all cases where the vessel is small, it will be best to place the large gun on a slide, to point always in one direction; but so that it can be either elevated or depressed at pleasure, while the direction can be obtained by means of the helm, as is commonly practised in gun boats.

PLACING THE ENGINES.

The engines now in use, are placed, very properly, near the centre of motion, and, as far as the velocity is concerned, they could not be put in a better situation for packets and mercantile purposes; but when intended for vessels of war, the great object is to place them where they cannot be damaged by shot; a consideration, which is paramount to every other. It is evident, that the waggon boiler and upright cylinder, are not proper for vessels of war; and in all cases, therefore, high pressure steam should be resorted to; the cylinders should be horizontal, and the steam should be generated either in tubes according to Gurney's Patent, already described, or in small boilers which could be placed under the water line. These boilers, and also every part of the machinery should be so fastened that those whose duty it is to examine them, should have access to every part, and there should be railing placed so as to guard against accidents. It would be of much advantage in action, if the paddle wheels and engines were constructed so as to work independently of each other, which has been successfully tried in America; and the reader is here referred to the introductory article, for an account of this improvement, and that of Mr. Castigin, which sets the question of the practicability at rest.

The paddle wheels of a steam vessel for cruizing, should be narrower than those for rivers, by at least one-third; and when the vessel has every thing on board, the paddle that is vertical, ought to be completely immersed; and no more. The many improvements which have been made on the paddles, and the manner of placing them, are detailed in the article on that subject, and in the specifications which are also given, to which the reader is referred. The stowage of the ship should be an object of particular attention; the *dead weight* should be kept as near the centre of motion as possible, and *trimming ballast* should be kept in proper cases, ready to be moved, and placed in such a manner, as to bring the ship perfectly upright, and nearly on an even keel, on every change of wind or circumstances.

CHAPTER III.

TACTICS PECULIAR TO STEAM NAVIGATION.

Having explained by the introduction to this treatise, that the tactics peculiar to Steam Navigation are essentially different from those required for sailing vessels, and that this science should be studied, as forming henceforth a part of the profession of all nautical men; it is proposed, without further preface, to discuss the theory and practice of Steam Navigation in all its ramifications; and I shall therefore begin, as in speaking of the construction, with steam ships of the first class, acting as cruizers.

The commander of a steam ship of war, should be well acquainted with the principles and nature of the engine, or he will not be able to decide whether the engineer, and those subordinate to him, are doing their duty as they ought, or not; and a perfect knowledge of the individual duty of each person connected with the engine, will tend both to the safety of the ship, and to her economy; but such knowledge will be peculiarly advantageous during the casualty of action, which is a period at which no person in a subordinate station should have any separate command; and it should never be in the power of the engineer, to put his own knowledge on a footing which might entitle or induce him to disregard the directions or the wishes of his superior, on the plea of ignorance on the part of his commander. This would undoubtedly be the case, were the captain and officers of a steam ship of war unacquainted with the nature of the steam engine. The commander of a vessel of war, or of any vessels, should be well acquainted with that which is now a part of his profession: he should, on taking command, examine the engineer and the men under his directions connected with the machinery, touching their scientific knowledge and qualifications. The engineer's crew should consist of

One Head Engineer, at	- - -	5s. per diem.
One Assistant Ditto	- - - -	3s. "
One Head Foreman	- - - -	2s. 6d. "
Three Stokers (for a 40-horse power)	-	2s "
And One Stoker for every additional 20-horse power.		
One Messenger	- - - - -	

The engineer and his assistant should have no duty to perform but their own; neither should the stokers be employed on any thing but the care of the fire; and they should be allowed a double quantity of beer, or other beverage, while the engine is at work: they should also be relieved every two hours, when employed. The stokers should be regularly bred to their calling. It is a mistaken notion, that any ordinary seaman is able to tend the fire; since a regular stoker will not only keep a better fire, and a more steady heat on the boiler, which is of great importance, but will save in fuel, what would soon pay the wages of the whole crew.

In a ship of the first class, (1,100 tons) there must be, as in a frigate, three lieutenants and a master; the lieutenant, who in a frigate has charge of the deck, must have also charge cf the engine room, assisted by a mate and a midshipman. But it would be a better arrangement, both for the service and the health of the officers, if it were taken in turns by the day, the week, or the month. In addition to these, fifty men would be sufficient to manage the ship, as the anchor, which is the heaviest part of the work, can be weighed by the steam engine, or a Philips' patent capstern. But the number will materially depend on the number of guns which are mounted on the ship.

OF ANCHORS.

The anchors necessary for a steam ship, may be considerably less in weight, than those required for a sailing vessel; first, because her masts, rigging, and upper works afford less hold to the wind, because her length renders her a better roader, and because she draws less water. The cable must be of iron, which should be stowed in boxes, and these can be used in trimming the ship. It may be shortened in by the capstern, in the usual way; but a messenger may be led from it to the shaft of the engine or other apparatus connected with this, and hove up with great ease; but in this operation, care should be taken not to set to the engine, until the anchor is casted and the fish hooked, or the velocity which immediately succeeds the action of the engine, might carry the pin of the anchor against the bow, to the injury of the copper.

IN ANCHORING.

In a calm, care should be taken that the ship have actually stern-way, by means of the engine, before it is let go, and a sufficient quantity of cable, (from 5 to 10 fathoms) according to the depth of water, should be veered to cant the anchor, after which a chain cable will never get foul.

TO ANCHOR IN A TIDESWAY.

The ship's head should be brought round so as to stem the tide, even if the wind is in the opposite direction; in which case, the ship must be steered from the anchor, as soon as it is at the ground; but if not, the ship must be observed to go astern by the land or by the lead, before the anchor is dropped.

IN RIDING AT ANCHOR IN A STORM.

The steam engine may be often used with great advantage when riding at anchor in a storm; because, by setting just as much steam as will ease the cable, it will both make the ship ride easier, and materially assist both anchor and cable. There have been many instances of steam vessels riding out a storm when every other vessel present has driven from its anchors; of which, the Superb in the river Medway, is a remarkable instance. There is often a crisis in ships riding at anchor near the top of high water, when, if the anchors and cables will only hold for half an hour, all would be safe ; in this case, three or four bushels of coals would save the ship and lives of the crew. It is also proper to have the engine ready if riding in a storm, that if the cable should part, from a bad link, or other cause, or in case the ship should be obliged to slip, in consequence of another driving athwart-hawse, she might be saved, by propelling to some place of safety, assisted perhaps by the storm sails.

IN A CALM.

When under weigh in a calm, it is necessary to attend to the trim of the vessel, which must be kept perfectly upright; which is necessary, both for the sake of the velocity and the engine, as the resistance will then be equal on each of the paddle wheels. For this purpose, a small instrument was invented by the late Captain Head, of the Honourable Company's Service, and as this valuable instrument will also denote the draft of water forward and aft, it may be considered one of much importance, as will more fully appear hereafter. In this situation, the sails should be furled, the yards and topmasts struck, and the running ropes all stopped in, because the velocity of the ship will cause her to pass so quickly, that the air will have the same effect in resisting the vessel's progress, as a light breeze of contrary wind. It is of great importance that the vessel should be steadily steered, as yawning is very detrimental to velocity, because it augments the friction of the water on the ship's sides, increases the distance, and deranges the equilibrium.

LIGHT BREEZE.

When a light breeze springs up in smooth water, advantage can be taken of it, even should it be four *points before the beam.* In this case the square yards and sails are to be kept down, and the fore and aft sails set; the first sail that will stand is the jib, and it is the most proper to set; but all the gaff sails and stay-sails may be set at the same time, provided the helm continues to keep nearly in midships; but as soon as the action of the after sail produces an effect on the helm it should be taken in, and as the wind comes further on the beam, the sheets of the sails should be eased, that they may just stand full and no more: but if the ship carries a weather helm, the jib sheet should be hauled in and kept flatter than the other sheets. These sails will always do good in smooth water, but they will often be of advantage when there is a little swell, which sometimes precedes, and often comes with a light breeze; as it will then tend to keep the ship more steady, and allow the engine to act more regularly. There are often cases, however, when the sails should not be resorted to; and these occur where the direction or strength of the wind is variable, in which case there will be more lost in trimming, and thus deviating from the course, than would be compensated by any trifling advantage.

LIGHT BREEZE ABAFT THE BEAM.

When the wind comes abaft the beam, it must be taken into consideration whether the velocity of the ship is not greater than the strength of the wind, which may be known by a feather dog-vane, constructed for the purpose, or by the smoke, if there happens to be any at the time. If the vane does not blow out well, or the smoke takes a forward direction immediately as it proceeds from the funnel, it is useless, nay detrimental, to make sail, unless to prevent rolling, when a lofty staysail should be set. If square sails were to be used, they would become backsails, from the velocity of the ship: in a five knot breeze the wind is so light, and often makes so little progress, that even a sailing ship often outruns it, by the effect of the impulse she has received, therefore a steam vessel will always be propelled faster than the wind, when she will not go more than five miles an hour before it under sail only, and her square sails should never be resorted to in such a case, or until a stiff breeze has sprung up.

LIGHT BREEZE BEFORE THE WIND.

When the wind is *right aft,* that is, when the ship is sailing in the direction of the wind, the square sails are not of use until it is strong enough to keep them full, and then it will be found that the sails set on one mast only will do more good than if they were set on both.

A GALE.

In a gale of wind, every thing about the masts and rigging, which holds wind and impedes the vessel, should be lowered on deck; that which cannot be taken down should be stopped in, and the masts left bare, with only the shrouds, which are necessary to support them. It is fully established by experience, that the best plan to make way to windward, against a gale, is to propel directly against it, commonly called, *in the wind's eye.* This is also consonant to theory; because, in the first place, the ship, being end on to the wind, holds less of it than in any other situation, and therefore her velocity is not so much opposed by the wind on either bow, nor has it the power to blow her head off in any other direction; secondly, because although the swell, or the waves of the sea, are acting directly against her progress, there is less surface of the water composing the wave opposed to her than if it fell on the bow, and, like the wind, it has not the effect of throwing her head off on either side; the surest way, therefore, to get to windward is to keep the steam ship's head directly against the wind and sea.

Great attention must be paid to the management of the helm at the moment of a squall or sudden gust of wind, or when a heavy breaker deadens the vessels way, when propelling against a gale, in which case the helm should be put in midships, when the helmsman will soon feel which way it ought to be turned to counteract the effects, and she will often be prevented from being forced from her course, by such timely and judicious management; but if every effort to prevent her falling off is ineffectual, no attempt must be made to bring her head again to the wind, until she has completely regained her velocity, which is done by steering for a few minutes about seven points from the wind, and then a lull or a moderate moment must be taken advantage of to put the helm down, and then her course will easily be resumed. As long as a steam vessel can be steered against the wind and sea there is no danger; this assertion however is not intended to convey the idea that putting the head to the storm is always the best or safest position a steam ship can be kept in: on the contrary, she would be much safer and easier, unless the swell is so short that her length is sufficient to overcome its effects, with her head two or three points from the wind's direction.

When her head is kept from four to six or seven *points from the wind*, the storm sails will be used to much advantage, and the steam may be kept up at a moderate force, which will be sufficient to keep her from falling off into the trough of the sea, which is the most dangerous position any ship can be in during a storm, and this is one of the cases where, in point of safety, the steam ship has a decided advantage over a sailing one. In the first place, she has exactly the masts, rigging, and sails, that a man of wa ro rany other ship would *choose* to have in a heavy gale; and by having these reduced masts made in the proportions already mentioned, she is able to show more canvas, consequently to keep her headway better; she will also be more weatherly, and will not be so apt to fall off. As she draws less water she will be more lively, therefore, under *canvas only*, setting the engine out of the question, she is a safer vessel; but when the engine is also set on, in addition to these advantages, the question of safety in a storm is beyond a doubt. With the steam ship's head in this direction, the sail should be balanced so as to allow the helm to be nearly a midships, and the rudder which, it must be remembered, is above the common size, should be chocked when the vessel is completely out of the track of other ships. When

THE GALE IS ON THE QUARTER,

The fore and aft sails on the fore mast should be set, but not those on the main and mizen masts, and the trim and helm should be particularly attended to, but too much of the trimming ballast should not be brought to windward, as the effect of her heeling in that direction would be to make her ship water. Moderate steam will be sufficient in this case, as, if it were too strong, it might do some damage to the machinery. Great attention should be paid to the valve, in this and the following case. When

SCUDDING BEFORE THE GALE,

The same sail is set in a steam as would be in a sailing vessel, viz. close reefed main topsail and foresail, or reefed foresail, close reefed fore topsail, &c. This is the period when a sailing ship sails fastest, but it is not the fastest point of sailing in a steam ship, although she is *equal* to the sailing one: but when scudding before the storm, it is impossible to help rolling, and as the paddles are now constructed, they will first be one side, and then on the other, out of the water, which causes an irregular action or resistance on the shafts; and as they will be sometimes both out of the water, when there will be no resistance for a few seconds against the engine, the piston would then go with too much velocity, if the full force of the steam was applied, and it is therefore advisable to use only a moderate quantity of steam, and the power of the engine not being available, it follows that the velocity will not be so great as if it were only a strong breeze with smooth water. The recent invention of paddle wheels is calculated to do away with this objection, and will also add much to the safety and utility of steam ships, while experiments which bid fair for success on this important point are now going on. Much attention must be paid to securing every thing belonging to the engine during a storm, and both engineer and firemen are required to be watchful. The present class of steam packets are said not to be well constructed for scudding, being too lean abaft, but it is certain that no accident has as yet happened from that cause, and it is probably a mere conjecture. That objection has, however, not been made to the United Kingdom, Erin, and Town of Drogheda, which have proved that they are calculated to withstand any storm, by having frequently and actually been at sea in the most severe weather and in all situations. We come next to

LYING TO IN A GALE.

It is understood by this term that the cruizing ship is merely to be placed in the situation most easy for her safety, without any intention of making way against the wind; and although the steam ship has the advantage of being able to assist herself by steam, it does not follow that she must do it, while the fact is that she is always prepared for a storm better than it is possible to prepare any other vessel. All sailing vessels must have masts, to ensure their sailing in moderate weather, which become preposterous in a storm, in which it is often necessary to cut them away to save the ship, while the substitutes are the very kind of masts and rigging and sails that belong, as of course, to a steam ship, though not so perfect for the purpose. The steam ship is dependent on steam only, the masts and sails being secondary; she is therefore much more effective, as being less exposed to injury from the weather. In lying-to in a steam ship, the try-sails, or reefed try-sails, according to the violence of the wind, are to be used, and the more sail she can carry the more steady she will be; but if the reefed try-sails are too much, the fore one should be taken in, and also the mizen one, as well as the reefed main and storm staysails.

OF HEAD WAY AND STERN WAY.

These are subjects of great importance, as they relate to steam ships, and which should be perfectly understood by all commanders and others, who have the charge of navigating them. The head way in a steam ship being, in the first instance, produced by mechanical power, does not partake of the combined effects of air and water, and is not liable to the deviations occasioned by the contrary action of these two elements, as in a sailing vessel the momentum is given by the power of the engine acting on the water, and continued according to the inertia of the body put so in motion, and it is also regulated by the same power. The headway, therefore, is neither instantly produced or stopped, and, in performing every evolution, this is to be considered. The act of diminishing the velocity is called "slowing the engine," because it is accomplished by permitting less steam to enter the cylinders, and this is done by partly closing the throttle valve, or the induction pipe. The vessel, by her own momentum, then retains her head way, which gradually diminishes until it is altogether lost, but this may be still sooner overcome by stopping the engine, which is done by cutting off the steam entirely, in consequence of which the paddle blades will *hold water*. Again, this can be done yet more effectually by backing the paddles, which is effected by causing the steam to enter the cylinder in the opposite way. Neither of these expedients should, however, be put into practice until the velocity, if above five miles per hour, has decreased considerably, as it might occasion some damage to the machinery. The more headway a steam vessel has, the more space she will require in assuming the opposite direction, and hence, if it becomes necessary to turn round in a narrow channel, or among shipping, or on entering a harbour, the engine must be "slowed," and the headway diminished. In picking up a boat, the headway must always be attended to, and the engine must be "slowed" when the boat is at such a distance as to permit the vessel to run by her own momentum before she stops. In passing other ships, the same precaution should be observed.

The effect of "sternway" is nearly the same, but the consequences are sometimes different. If it should be calm, and the steam vessel is without motion, while it is required to get her head round in the opposite direction, this evolution will be performed in one-fourth less time, and in one-fifth less space, by giving the steam vessel sternway than by giving her headway, through the force of the engine. This is to be accounted for by the action of the rudder being more free from the influence of the eddy, or back water, and by its being constantly kept by the action of the water upon it, close over to the side of the stern-post, making a constant angle with the keel of about 36 degrees. All the water which acts upon the rudder passes it thus from astern in a horizontal direction, while, on the contrary, when the vessel has headway, the action of the rudder is diminished by the eddy which constantly follows the ship, to fill up the water which she displaces, and the water which acts upon it does not pass it in a horizontal direction, and that which the ship has passed over, by rushing up to join, filling up the water displaced by the ship, does not take the direction which has most power on the rudder.

The following diagrams, representing the experiments actually made on this important subject, will best explain the facts.

Fig. 19.

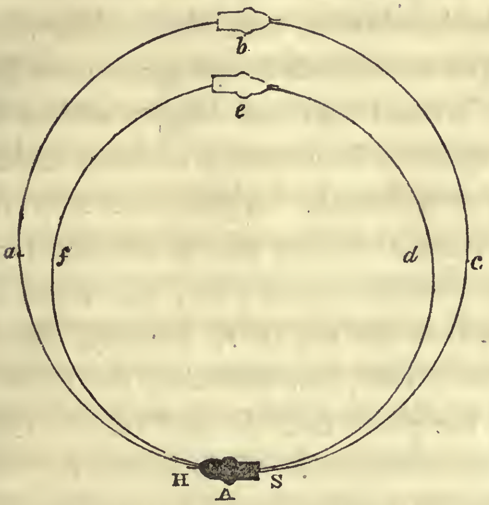
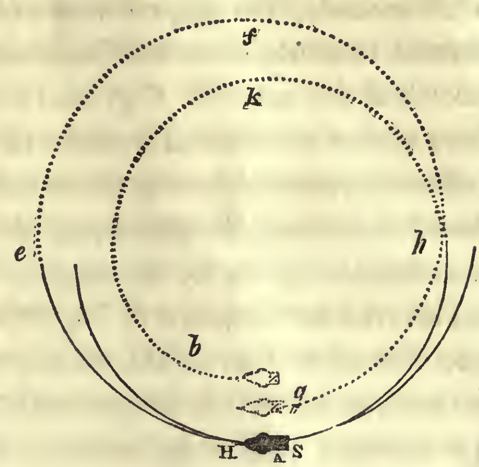


Fig. 20.



Let A (Fig. 19) represent a steam vessel at rest in a calm, H being the head and S the stern; the helm was put hard to starboard, the ship was impelled *ahead* by the power of the engine, which made thirty-six strokes per minute, when she described the circle *a b c*, eight times her own length in circumference, having returned to the spot from whence she set out in four minutes and two seconds. The vessel being again placed in her original position, and the helm put a starboard as before, the ship was impelled *astern* by the power of the engine, which made thirty-six strokes per minute, when she described the circle *d e f* six times her own length in circumference, having returned to the spot from whence she set out in three minutes and seventeen seconds, proving that in a calm, when no power acted upon her but the engine, the evolution can be performed in one-fourth less space, and in one-fifth less time, by what is called a *stern-board.*

The second experiment that was made in a calm, is also explained by the same diagram. The steam vessel was placed a starboard the helm-fast, and *head-way* given by the engine, making 36 strokes per minute as before, when the vessel had reached the point E. Fig. 20, which she did in 20 seconds, the engine was suddenly slowed, and the paddle wheel allowed to work, so as neither to impel nor impede the progress: she then described the curve E *f g*, and she arrived half her length within the place where she started from, in the space of 9 minutes, 9 seconds, making a circumference of seven times her own length. Again, the ship was placed in her original situation, the helm as before put to starboard, the same impulse given by the engine to produce stern-way; and when she had arrived at the point *h*, Fig. 2, which she did in 17 seconds, the engine was slowed as in the former case; she then described the curve *h*, and arrived her whole length within the place that she had started from, in 6 minutes, 2 seconds, making a circumference of six times her own length. From these experiments, which were repeated several times, it is manifest that the evolution of reversing the vessel's head, is performed both in less space, by a *slow motion*, and by what is termed a *stern-board*, than in any other way; a fact, which I shall have occasion to recur to hereafter, in treating of the management of these vessels, in situations of much importance.*

This mode of changing the direction of the vessel's head, may be resorted to in a pretty strong breeze, but never in a storm, except in cases of great emergency; such as, to prevent collision, to avoid rocks and shoals, or to escape being run down. When however it can be done with safety, it saves both time and distance in all situations.

* It has often been suggested, that a rudder on the stern would be a great advantage; and although the experiments which have been made have not led to an adoption of that plan, there has no reason been given why it should not be adopted; and it certainly is a great desideratum, to have a rudder fixed on the stern, which would be firmly checked, and allowed to traverse at pleasure.

OF STEERAGE.

This subject is also one which demands much attention. The helmsman of a steam vessel, should be thoroughly acquainted with the wit of steering; he should, in fact, be able to decide even by the *feel* of the spoke of the wheel which he holds in his hand, how it ought to be moved, without the common indication of the compass, or of the ship's head, in coincidence with a distant object.

In steering in calm weather or light breezes, a small helm will do, and will increase the velocity; but in rough weather, the helm should be *kept alive*, both for the ease of the ship, of the rudder, and also the helmsman. Before the wind, there is little difference between steeering a steam vessel, and a sailing vessel; but it is the duty of the steersman, to inform the officer if she carries, in consequence of the balance of sail, either too much lee or weather helm, as it is also the duty of the officer or pilot, to enquire respecting that fact, and to take steps accordingly. In steering a steam ship, which is propelling against a strong wind and a head sea, the helm must be given quickly, to keep the wind right a-head; and a look-out must be kept by both, for seas which come on either bow, which is often the case, when the ship's head is opposed to the wind; and the helm must be put so as to counteract its effects, by luffing to receive it, otherwise the shock occasioned by the sea, may throw the vessel's head off in the opposite direction, and the headway being lost, she may be driven completely out of her course. In managing the steerage in such cases as this, every thing depends on the man at the helm, whose attention should not be taken off, and the regulations on that point should be most strictly enforced. The subject of steering will however come under review hereafter, when specific reasons for recurring to it may arise.

GOING OUT OF HARBOUR.

Steam vessels have peculiar advantages in going out of harbour. The directions of the wind and tide, are of no importance to them, while those are of the utmost consequence to a sailing vessel; and it has been proved repeatedly, that they can get to sea, when no other kind of vessel can break loose. If the weather is moderate, and the steam is ready, all that is required is, that the head of the vessel should be canted seaward, or in the direction wanted, and the engine set on; but too much velocity ought not to be given until fairly clear of the harbour, especially in narrow waters. The velocity should not be permitted to exceed five miles per hour, and by attention to this regulation, many accidents would be prevented, such as running down boats, getting foul of ships, &c. The look-out men, or the pilot, should be placed as mentioned in the article of rules and regulations, and no other person should be allowed to interfere or speak to the helmsman; while the people on deck should be prevented from standing between them and the bow, to intercept his view of the objects before the ship. In case of accident, an anchor should be kept ready, and stern and bow ropes kept at hand. The engineer also, should be ready at a moment's warning, to slow, stop, or back the engine; and the sails which may be wanted, should also be ready. Where a bar-harbour is in question, the bar ought to be approached with caution; but as soon as it is ascertained that there is enough of water to float the ship, and the determination has been made to try, the full force should be set on, to keep her as short a time as possible on it, and to increase the velocity, which tends to prevent or diminish her *pitching* and *scuding*, and therefore renders her less liable to strike on the bank. In consequence of the invention of steam vessels, it is no longer necessary to build piers out into the channel tide, in order to get sailing vessels to sea, which has been often done at great expence, perhaps to be washed away in the ensuing storm; because, if sailing vessels cannot get out so as to loose or make sail, they can be towed out by a steamer, and cast off when clear of every danger.

COMING INTO, OR TAKING A HARBOUR.

In approaching a harbour, the great anxiety of the captain of a sailing vessel, is for the safety of his ship, in event of his not being able to reach the port, in time to get in; which often happens from fog, variableness of the wind, and other causes; whence he may find himself embayed in the beginning of a gale. It may indeed be justly said, that no harbour is good for a large ship, let it be ever so commodious, easy of entrance, &c. unless it has a *good approach.* This is the case with Milford Haven: if it is missed by a ship in thick weather, and its entrance passed, either to the southward or northward, there is no redemption for the ship, if caught in a gale. The steam vessel however may approach any coast or harbour without fear, and calculate positively when she must reach it; if prevented entering by fog or thick weather, she can, by plying to windward, ensure such an offing as will secure her a long night's drift, in four hours; besides which, she can instantly avoid any shoal or danger which may appear.

If we now suppose, that a vessel of this nature has approached, and is about to enter, her sail should be taken in in good time, her fenders, ropes, &c. got ready every thing, according to the established rules and regulations; and the deepest water being chosen, she ought to enter at the rate of five miles per hour; but if the harbour has a bar, she ought to go over it at her greatest velocity, and slow the engine after she is over.

If the harbour has piers built out into the channel tide, as before mentioned, such as at Dover, and if the tide and wind passes the mouth of the harbour in the same direction, the greatest caution and skill is necessary to gain the entrance. She must steer diagonally across the wind and current, keeping the vessel's head so much to windward of the weather pier, as will keep its bearings always the same, and appear as if intending to weather it, until just time enough to bear up and clear it to leeward; but the moment that her head is between the piers, is the crisis when the helm should be put a-weather, because the bow will have entered the slack or eddy water, while the stern is in the current; and unless counteracted, in that manner by the helm, would occasion her to run on the weather pier; at the same time, care must be taken not to run her head too much off, to avoid running on the lee-pier. In steering through a narrow or crooked channel, or in passing between two ships lying ahead and astern of each other, it is always necessary to slow the engine, keeping ready to set on the steam when necessary. It has been already explained, that less space is required by a sternboard; and it is often advantageous to have recourse to that method, instead of making a sweep to bring the head round.

In bringing the vessel alongside a pier, it is not necessary, as in a sailing vessel, to bring the vessel's head about, to stem the tide and wind, even if in the same direction. It can be done with equal safety, and in much less time, by stopping the engine when the vessel's side is close, and nearly parallel to the pier; then by backing the engine and reversing the helm, she can be laid alongside of it, or of any other object, by steering to. In the same manner, a berth may be taken without the trouble of ropes and hawsers, and with less risk of doing injury to her self and to other vessels.

LEE SHORE.

The steam vessel has in this, the most trying of all situations, a decided advantage over the sailing vessel, by being able to ply to windward, either on the appearance of a storm, or before it materially increases, by which she will obtain, in an hour or two, an offing that would ensure her safety. She may be able to weather a point, which would give her many leagues drift, to gain a harbour, or to get shelter from a point of land, when it would be impossible for a sailing vessel to do either. If actually caught on a lee shore, and any thing should happen to her engine, she will come under her canvas, which is just of the description suitable to such a situation; and even if she had nothing but her storm sails to depend upon, she would by them be much better calculated to beat off than a vessel of any other description. Steam vessels thus caught on a lee shore, should get all the yards and the topmasts on deck, with the whole of their gear, carry the gaff, or large fore and aft sails as long as possible, and then the try-sails; and although they would then have double the sail set in proportion to their size, they would be able, from having less weight aloft, and shorter masts, to carry their sail much longer than sailing vessels. When it blows too hard for the sails above mentioned, they must be shifted, (beginning with the mizen, and so going on foreward to the main and fore) with the storm staysails.

When every effort by sailing and propelling has failed, the anchor is the last resource, in which case one anchor only should be let go, and if room, a great scope of cable. It has been proved, that in an open heavy sea, a ship will ride longer with three cables on end, than if two anchors were let go with a cable and half, or two cables to each, and she will be much less liable to *ride under,* or to take water in over the forecastle; and in this situation, she has great advantages from the masts being so much less in proportion. The vessel being longer, is also an advantage; and if there is a heavy sea, or a lee current, her having a less draft of water, is also comparatively in her favour.

The steam engine, even with a low power, would be of much service, in assisting the cable and anchor.

ON BEING TAKEN ABACK.

This situation, which in a sailing vessel, is often attended with serious consequences, is of no moment to a steam vessel; the diminutive proportion which the masts and sails bear to the hull, could not, on such an occurrence, at all endanger the ship, and the sails are more easily trimmed, or taken in. On the appearance of unsettled weather, the square sails may be dispensed with, when they cannot in a square-rigged vessel, and therefore the emergency is more easily guarded against: and she may be said in this respect, to have all the advantages of a fore and aft rigged vessel.

ASSISTING SHIPS IN DISTRESS.

This is one of the most interesting services on which a steam vessel can be employed, and one in which her superiority is peculiarly manifest. When the sailing vessel has great difficulty in approaching a ship in distress, during a fresh gale, the steam vessel can do it with ease.

If the ship is sinking, she should propel into the line of drift which the vessel takes, in order when she actually sinks, to be in the best situation to save those who are swimming and clinging to pieces of wood, and she can push on to the spot where men are seen in that situation, or in the direction in which voices are heard. When picking up a boat deeply loaded with men, she should slow and stop the engine, or by a fore or back stroke, keep the vessel exactly to windward, so that she might drop alongside, when head and stern fasts should be thrown, and ropes ready to cast to the crew, in the event of the boat swamping. If the ship is on fire, the steam ship should keep exactly in her wake, and she may approach much nearer than any other vessels; because, her sails being all taken in, she does not run the risk of having the fire communicated to her, which a sailing ship does. Indeed, if she is certain that the *magazine is drowned,* a hawser may be fastened from the bow of the steam ship to the weather quarter of the vessel on fire, and then boats may be hauled by small lines from the one to the other, by which the sufferers would be much more safely and quickly conveyed from the burning ship. Many lives, and also treasure, might thus be saved; which could not be done by any other than a steam vessel.

The superior efficiency of a steam ship is no less manifest in the assistance she is capable of affording to ships which have, by any accident or untoward circumstances, been driven on shore. If the ship or wreck can be approached at all by anything else, she surely can by a steam vessel, and very often the steam vessel can approach a wreck when it is impossible to come near her in any other way, and it will be shewn that the assistance she can give is most effectual. First, let us suppose the ship to be aground on a bank head, which is the most common occurrence of the kind—the steam ship should approach by backing in her stern towards the stern of the ship that is on shore, and going as near as the shoal will allow, take in the end of a stream or bower cable, which is made fast to the main mast, timber heads, or otherwise securely; then from 20 to 30 fathoms of the cable should be faked on the deck of the steam vessel, after which it should be made fast on board the ship, it having been handed out of the stern-port, or if from the poop, it must be guyed as near as possible to the water's edge, as the old plan of "getting a ship off the way she went on" is generally the best, and is almost always right astern. The steam ship having then got her steam up to the highest pressure she can with safety, should set on within half a point of that direction, but if the ship's head has either fallen off or *come to* since she struck, this half point, which is to assist by giving the ship a little of an indirect motion, in order to overcome the power of suction, should be towards the side which her head has removed, which will tend to bring her keel again into the track it had when she first grounded. The cable should be payed away after the steam ship, and when all is out and the cable begins to come tort, the crew should sally the ship by running to the lee-side, or to the side towards which the steam vessel has tended most, carrying from the opposite side all the weight they can carry at that instant. If this does not succeed, the process should be repeated, and in the mean time the ship should be lightened by starting water, &c. When prepared, let the steam vessel again set on the engine, but steer half a point on the other quarter, and let the crew give her another sally. If she still continues aground from the tide having left her, or from some other cause, and it becomes necessary to lay out a bower anchor, the steam vessel is again far better qualified than any other kind of vessel for this service; she should approach, taking care to make use of the fenders, which will be found described in their proper place, as near as possible to the ship, and hang the anchor to the stern or some other convenient place, and if for only one cable in length she can manage to run out the whole cable with ease and exactness, the ship on shore only has to "pay away cable," and all the trouble of boats with warps and hawsers, besides the time, is saved. If two cables on end are to be laid out, or if she has to cross a tide or current, at least one half of the whole length of cable that is to be so laid out, should be coiled or faked on the deck of the steam vessel, by which means she will be able to place it more exactly in the direction required, by steering so as to allow for the bight of the cable's being carried down the stream. In weighing anchors, and in lightening the ship, the assistance which a steam vessel can give is far more prompt and efficacious than can be afforded by any other vessel.

If the steam vessel herself happens to be run aground, the engine ought to be instantly backed, and the vessel sallied in the manner before described; if that is not sufficient she should be lightened by starting water, &c. and an anchor being laid out, the cable or hawser may be successfully hove in by means of the engine, and the vessel, and probably the lives of the crews might be saved, when all on board a sailing vessel which has not these advantages might perish.

If a steam vessel takes fire, the steam engine can be used to subdue it, and if the vessel is now on shore, in order to let the passengers escape, care should be taken that in doing so the paddle wheels should be kept clear of the ground, in order that the engine may not be prevented working and being employed in pumping water; the same may be observed if she is in a sinking state, and it would be well if the paddle wheels were all constructed so that they could, if required, be worked separately or in opposite directions, as has been done in America, in consequence of an accident by fire to one of their steam ships, which being run on shore to give the passengers an opportunity of landing, one of her paddles got so locked by the bank of the river that the engine was stopped, and the vessel was consequently burnt. Fire buckets and lanyards to them should be at hand, in order to quench fire in the event of accidents, which however are not more likely to happen on board a steam ship than any other vessel.

EXPLOSIONS.

When steam engines came first into common use, accidents of this kind took place, which seemed to lead the mind of the public to imagine that steam navigation would always be exposed to that evil: but these events only turned the talents and genius of scientific men to discover a remedy, which has certainly been accomplished in such a degree as to put the question at least beyond accident; and although some explosions have taken place within these few years, these can be traced to causes which may be said to be now completely removed. It is, however, very easy to cause an explosion wilfully, and indeed ignorance of the properties and nature of steam may still occasion it. The principal causes of these accidents, have now been removed; the boilers are no longer made of cast iron, the principal safety valve is so enclosed and protected that it cannot neither by accident nor design get so loaded as not to act, and lastly, high pressure steam is very seldom used; but the mode of generating high pressure steam by means of wrought iron tubes instead of boilers, which has been already mentioned, has been lately brought to great perfection, and has rendered them equally safe with low pressure or condensing engines, with the great advantage of occupying only one-third of the space, and one-tenth of the weight; and if a shot should break or damage any of these tubes, no explosion would take take place, as the fire would be put out by the setting free of the water. The account of this kind of boiler is given in the 1st Chapter, together with an engraving. To prevent explosion, it is only necessary to examine and see that the boiler is perfectly safe every time that it is cleaned, which it should be as often as it is used. As soon as it is sufficiently cool, after the fire has been removed, the enclosed safety valve should be cleaned and again secured, During the time the engine is at work, the engineer or his assistant should attend constantly to the gages which regulate the pressure of the steam, and not suffer their attention to be diverted from them on any account. If any explosion does take place it must be from ignorance or design, and although none can take place from negligence, still considerable injury may be done to the boiler by allowing the supply of water to be either too much or too little, and this is one of the reasons why a thorough knowledge of the steam engine is so necessary to the commander, who must be held responsible for every thing.

BOATS AND ACCIDENTS TO BOATS.

Every steam ship should have her boats hung in tackles, and ready to be lowered at a moment's notice. These boats should have a flat floor, and be rather broader than usual in ship's boats. There should be also two life buoys, or more, according to the size of the ship, suspended by slip ropes over the quarter, that on any persons falling overboard, or in the event of a boat being upset or swamped alongside, they might be dropped overboard in a moment. If the steam ship has four buoys, two of them should have a two-inch line of about ten fathoms in length attached to them, with one end fastened on board and the other to the buoy, by which it might be hauled in, and also any person who had hold of it, without the trouble of lowering down a boat for the purpose. When boats approach a steam vessel, they should lay in both the bow and the after oars, and indeed all but two oars on each side, and lie to with the head nearly in the direction in which the steam vessel is steering, cautioning every person to sit still in their places until the boat is fairly alongside and her way stopped, when they should rise from their seats one at a time, as they ascend. The man in the bow, who has hold of the rope, should never make it fast, but hold it in his hand with a turn round the fore beam or a timber head, and the steersman, who has the stern-fast, should hold it slack in his hand, without making it fast any where.

In picking up a boat, the steam ship should steer towards her, keeping her a little on the bow, and on the same side on which she wishes her to come to, that the persons in the boat may be aware of their intentions. The commander, pilot, or other officers who have the charge, must call "attention" to the engineer, who should then keep in his hand the bar or lever of the throttle valve, ready to execute the orders he might receive. The engine should be slowed just in time to let her way be expended when she arrives at the boat, which distance must be determined by the commander, according to the velocity, the state of the wind, the sea, and the weather, and also the size of the ship and the sail set. If he sees that he will have too much way, the engine should be stopped or backed; and, on the contrary, if she appears not to have enough, the engine should be gently set on, to enable her to reach, when both a bow and stern-fast should be thrown on board. The practice of towing open boats is productive of much evil, and ought never to be allowed. When a person falls overboard the life buoys should be slipped or cut away, and the engine immediately backed; and the boat should not be lowered down until the veesel has lost her way, when it should be done by the proper people stationed to it, and not by persons unaccustomed to that kind of service, which is often the cause of the loss, not only of the person who has had the misfortune to fall overboard, but also to the crew of the boat, by letting one end down before the other, getting the ropes foul or jammed, &c. When this or any other service is performed by boats, they should be hoisted up in their places before the engine is set on, so as to give the ship any headway.

CHAPTER IV.

NAVAL WARFARE BY STEAM SHIPS.

THE revolution which the introduction of steam has made in naval tactics having been already explained, it remains to treat of the different heads under which steam vessels may be arranged when applied to naval warfare,—namely, as auxiliaries to men of war—as a separate force—as a protection to trade—and as a defence to the nation. When a steam vessel is attached to a ship of the line, her province will be to assist the ship in the performance of every evolution, and as she could be of no service in a general action unless she was exposed to the fire of the opponents, (a case not to be contemplated when a large ship can so soon sink a small one,) the necessity of constructing vessels for the very purpose will be apparent. It is true the steam vessels now in use might suffice to assist ships in getting into action; but after such a vessel was within the range of shot her utility would cease, although if rendered proof against shot, she would be of material advantage. Supposing, therefore, that a vessel of this nature, destined to assist ships of the line, was sufficiently fortified to protect herself and machinery at the distance of 600 yards, she might be usefully attached to a ship, or to the fleet, as an auxiliary in numerous situations and cases. I shall commence with

CHASING.

This important and interesting portion of naval operations, has by the introduction of steam, suffered a complete revolution, and in many instances its principles and practice are reversed. Formerly, the ship to windward was universally allowed to have the advantage, and to obtain the *weather gauge* was considered by a British officer the first step to victory; but now the ships or fleet to leeward will have a decided advantage, because it will always be in their power to bring the ships to windward to action, by doubling or trebling the number of steam ships to the chasing ships. For instance, we shall suppose that the hostile fleets each consist of 20 sail of the line, and that each ship has a steam boat attached to her; it is evident that if in both fleets the steam vessels were applied individually to each ship the rates of sailing would be equal; but if the fleet to leeward applied *all* her steam vessels to one half of the fleet, that is, two steam vessels to each of the ten ships composing that half, the consequence must be that they would come up with the rear of the weather squadron; for if their opponents did the same, they would tow away one half and leave the other half unprotected, and would eventually be obliged to bear up to their assistance, when all that they had gained would be lost, but it would be always in the power of the chasing ships to return to their friends if too hard pressed. On the contrary, if the fleet to windward is chasing that to leeward, the whole would be before the wind, when the difference in sailing between steam vessels and sailing ships would be so little, if the breeze was fresh, that the event would not be much accelerated by that or any other method. In chasing, therefore, the weather gauge is no advantage, yet the state of the wind and weather must be considered. If there is a fresh breeze, so that the rate of sailing between steam and sailing ships is nearly equal, let their positions be what they may the chase will be longer, both in time and distance; and indeed it will often be judicious not to apply the auxiliary steam ship until the wind has moderated so considerably, that the application of steam would increase the velocity of the ship by one-third.

Ships of the line, will generally keep their auxiliary steam ships in tow when they are not wanted; but the rope used to tow the steam ship, needs not be of so large dimensions as the one by which the ship is to be towed, because, in most cases, the steam ship will sail nearly as well as her consort. The main tow rope should be the size of the stream cable, and led from the weather or lee hawse hole, along the weather or lee side accordingly, and a sufficient quantity of it coiled or faked on the poop, to reach the steam ship when her tow rope is shortened in; and when received on board, it should be taken in over the stern, and made fast to the stout timber heads which are built into the frame of the vessel for the purpose, and fastened in the strongest manner. The bight of each tow rope, must be hung with slip ropes, with men stationed to cast them off as the rope begins to bear a strain. The steam being up, the vessel will pass the ship on the same side with the main tow rope; and, as it is slipped, the other can be triced up in the same manner. A preventer should then be carried from the other quarter of the steam vessel, and made fast by a *hitch and seizing* to the main tow rope, from three to five fathoms from the stern. Each end, and every part exposed to rub or chafe, should be well *served or parcelled,* and the tow rope veered, or the preventer shortened until they bear equal strain; but the use of this precaution, is no less effective in relieving the nip of the tow rope, which is the part most likely to give way, than in assisting the helm. If the steam vessel, owing to the effects of the wind or sea, carries a weather helm, this disadvantage will be much counteracted by the strain of the tow rope being made greatest on the *lee* side, which is done by veering a few feet of the part fast on the weather quarter: and if she carries a lee helm, it will be counteracted by veering the lee part. But in propelling directly against the wind, the main tow rope should be kept always in the centre, by an equal strain being kept on both.

The length of the tow rope, must also be suited to circumstances. The shorter it is, and the nearer the auxiliary steam vessel is to the ship, the less room will be requisite in performing every evolution; and what is of importance also, the easier will it be for the ship to supply the vessel with fuel; and the most convenient distance in smooth water, will be the length of the vessel, as at that distance, fuel could be sent by a traveller fixed on a rope between the mast heads, which shall hereafter be described. But if there is much swell or sea, the main tow rope should be lengthened, according to the degree of motion, to one-third of a cable, which, in all cases, should be sufficient.

The steam vessel which is the largest and heaviest, is the best calculated for towing a ship against a sea, as her own momentum will often be sufficient to overcome the momentary shock or stroke of the wave, when a vessel of more velocity, but less solidity, would be checked by its effect. Great care should be taken in steering after the steam ship, and enquiries should be made, how the steam vessel carries her helm, that the ship may be steered so as to assist in counteracting any disadvantage. If the steam vessel carries a weather helm, the ship should steer on the weather quarter, or a little to windward of the wake of the steam vessel, and the contrary, if she carries a lee helm; while, if a midships, she should steer in her wake.

It will be a necessary precaution, to keep the small tow rope fast, with as much strain on it as will keep it out of the water, when the other is at its extreme extension; for in event of any accident to the main tow rope, it would hold, with the engine slowed, until the main one could be replaced, and thereby save much time and trouble. Besides which, if any thing was to happen to the machinery, it would be ready for towing the steam vessel until it could be repaired.

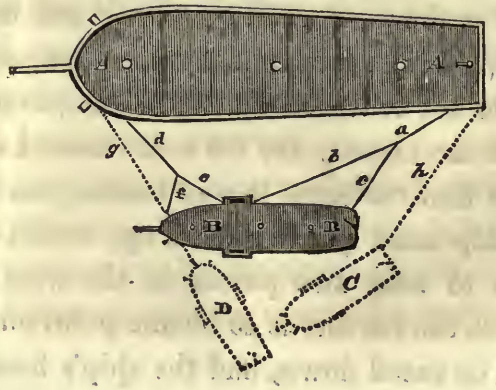
A good look out for these accidents, should always be kept; and in the event of any derangement of the machinery, the ship should pass the steam vessel, by keeping her to the same side on which the tow rope is triced up, the slip ropes of which, should be tended and cast off, as the strain comes on them. If two steam vessels are towing one ship, their tow ropes should be independent of each other, which will be found more convenient for performing every evolution, as well as safer in event of accidents. In this case, the steam vessels must keep their tow rope on the quarters nearest each other, and the ship should steer evenly between them, so that, in the event of an accident to one, the ship will pass her, obeying the directions already given.

In towing a large ship directly against the wind, which must of course be a light breeze, all the sails in the ship should be furled, the yards hoisted up, and braced sharp, and the ropes stopped in every where that it can be done, in order to make every thing hold as little wind as possible. As soon as it is found that the ship cannot be towed faster than she could beat to windward, sail should be made, and the yards braced up as sharp as possible; she should then steer just so as to keep the sail lifting, taking care to keep the chase on the same line of bearing, especially if she is right in the wind's eye; a situation which makes every change of wind an advantage to the chaser. In sailing vessels, there is no positive rule for bracing up the yards and trimming sails by the wind, because it is often found, that a sharp ship which draws much water, will bear her yards sharp; and although she does not go so fast ahead, she will weather a ship that sails much faster, but which will not bear the yards braced sharp, or keep so good a wind. In the case of having steam vessels as auxiliaries, it has been found, that all ships will get fastest to windward, by bracing every thing very sharp, and keeping the sails *cleanfull*: but if the vessels chaced do not brace sharp, and attempt to escape, the same must be observed, in the chaser, the lee brace must be checked, and the steerage managed so that the same line of bearing may be kept.

In tacking, the ship must put her helm up, until the steam vessel (if only one) is brought to bear two points on the weather bow: if there are two steam vessels, the lee one is to be one point on the weather bow, when the helm is to be eased down, and the ship's head kept so, that the steam vessels should appear on the same bow, until the head yards are hauled. The steam vessels, on the other hand, should not put down their helms until commanded to do so from the ship, and then they should take a considerable sweep to let the ship get time. It is found, however, that if the steam ship is long in her proportions, she will take as long a sweep as the ship; yet the helm ought never to be put quite down, as it tends much to diminish the velocity. In wearing, the ship is to bring the steam vessel or vessels in like manner on the lee bow, when the command will be given to put the helm up, and the ship should follow, keeping the vessels always on the same bow, until the evolution is performed. It will be necessary always to keep men by the tow ropes, ready to veer in case of the occurrence of any jerk or strain, greater than the ropes are able to bear. A surge or two at that moment, might, by easing the strain on the rope, save it from being broken, and be the means of avoiding much consequent trouble.

The ship having now approached her opponent within gun shot, it becomes necessary for the auxiliary steam vessel to attach herself in a manner that will make her of the greatest use, and under the least possible exposure. To effect this, she must be kept as near as can be on the opposite side to that of the enemy: and two ropes should be attached in the manner represented in the diagram.

Fig. 21.



Let A A represent the ship of the line, B the auxiliary steam vessel; *a b* is a tow rope leading from the after port of the ship to the fore towing timber heads of the steam vessel, but guyed to her stern by the rope *c*; *d e* is a tow rope from the bow of the ship leading to the towing timber-heads, but guyed to the bow by the rope *f*. In this manner, the steam vessel, by backing or propelling with the engine, can give the ship either head or stern-way. The figures at D and C denote the position of the steam vessel in turning the ship by the head and stern, which is done by slacking the tow ropes and guys, except that one at the head or at the stern, according as it is required to turn the ship and propel or back the paddles. The auxiliary steam vessels should be provided with long poles to keep off the ship, and also the fenders which are described in the chapter of Rules, &c. The ship being placed in the most advantageous situation, the auxiliary steam vessel may now be employed in annoying the enemy, and may without difficulty take up a situation the most eligible for effect, and at the same time out of the reach of the enemy's shot, while should her assistance be wanted she is at hand to render it. But after the action is concluded between the ships, it follows that another battle must take place between the steam vessels on both sides, and on this part of the action the victory depends, for it is only those who have the superiority in steam vessels that can carry off the dismasted ships. A ship of this nature may indeed be employed to destroy those whose masts are still standing; and if the weather is moderate and the sea smooth, no ship can escape, as the flotilla of steam boats which remain to the conquerors can pursue, overtake, and dismast or sink those who attempt to escape. Again, in shifting prisoners, it is obvious that it can be done with much more expedition and facility than by boats. The wounded also can be immediately taken to the nearest hospital, and the lives of many saved by it; and finally, the prizes can be towed into port, and the necessity of jury masts entirely done away.

The methods which must be employed by steam vessels in attacking each other, and in defending against attacks, must now be taken into consideration, and these may be said to be of the highest importance. As flotillas will assume the character of a battle between armies, and their dispositions will be extremely similar, the main body of the flotilla will be composed of powerful vessels, whose paddles and machinery must be well protected, and there must always be a *corps de reserve* to supply the places of disabled vessels, and to support any part that may be broken and penetrated by the enemy. The following will be the order of sailing best calculated for 60 sail of steam ships.

Fig. 22.

The centre division is represented by the letter A, the flag-ship *f* leading the van. This division consists of 15 vessels, the first line consisting of four taking their station from the flag by keeping her on their bow, from two to four points, according to the signal, and which will regulate the position of the whole; B and C, the other divisions, following the same by their leaders, and leaving a space between each division sufficient to contain one half of a division, which must depend, as well as the distance to be preserved from each other, on the state of the weather and smoothness of the sea. By this arrangement each vessel is kept out of the wake of her next a-head; so that if any accident happens she will be in the best position either for assisting or avoiding her; it is also the best adapted for forming the various positions of attack and defence. Until the steam vessels are constructed of a much larger size than at present, the line of battle will not be put in practice, but it will be formed more quickly from the order of sailing in two or three divisions than in any other way. The division A, Fig. 22, represents this evolution; the first line of vessels will open to allow the second to take a position between them, and the third and fourth will divide and take up their stations as described by the dotted lines. The division B represents another mode of forming in two lines, which is the most approved plan, being the most difficult to penetrate and throw into confusion. The column C represents the methods of altering the course, all of which movements must be done by preparatory signals. In stationing the vessels in the order of sailing, care should be taken to place the fastest and most powerful in the rear, for in every evolution they will necessarily have a greater distance to propel in order to obtain their station. The reserve, D and E, are placed in the position the most advantageous to supply the places of disabled vessels, and to protect the fuel transport if any are with the flotilla. In changing the course to the opposite direction, whether in the order of sailing or the line, much time and space will be saved by doing it with a stern-board, as represented in the diagram, Fig. 23, and this must

Fig. 23.

also be done simultaneously and by preparatory signal. In closing from a single to a double line, the steam vessels which are ahead of the flag or centre ship, must perform :he evolution by a stern board, and those ahead by propelling, as represerted by the diagram, by which the line will be shortened in the quickest way.

Fig. 24.

TIE MODES OF ATTACK.

The modes of attɔk in an engagement between steam vessels are more various, and wi' depend more on the skill both of the commander in chief and every aptain individually, than in any former system of naval warfare, but thre are also several general laws which are essential. The first is, that nuaber, although inferior in force, will often have the advantage, and it wll rarely happen that three small steam ships will not capture two large ones. While an engagement is going on between two and two, the uıoccupied one will always be able to take a position to destroy the othr, or to disable them, and decide the conquest; it will therefore be always the best plan of attack, to double on the adversary as soon s possible, in order to disable him immediately. To effect this the doʋle column is necessary; and each ship of the enemy attacked by two, eaving the rest of their line unoccupied to repel an attack, the flotillashould be formed in a double line, in order that they might be better ale to prevent doubling upon them, and that they in their turn might louble on the assailants. This will also be the province of the ships in reserve, which should always amount to about one-fifth of the whole flotilla.

The contest in steam vessels, will often be decided by boarding, although there will no doubt be very formidable missiles, &c. made use of to prevent this; but there will be the same on both sides, and with equal advantage. Another mode of attack will be to disable the antagonist by collision. The stem or bow will always be the best fortified, and the strongest part. If a steam vessel therefore can be made to strike the side of her opponent with considerable force, it must be fatal; while great skill in the management of them will be requisite, both in the attack and defence; a nadvantage which can be obtained only by a perfect knowledge of the theory, and by considerable practice: and it is here that the superiority in number, will succeed against a superiority in size and force, and that actual weight and strength will constitute a material advantage.

The next part of these tactics to be illustrated, relates to cruizing in a single steam vessel of war. There can be no doubt but in all future wars, steam vessels will be used as cruizers. The greatest quantity of fuel which a steam vessel has been found to carry, is about 600 hours, or 20 days; and if no greater improvement is ever made, it is sufficient. A cruizing steam vessel will never use her steam, unless in chase, or in making a passage. She will always be under sail, until a suspicious stranger is discovered, when the steam will be raised and applied, just as a sailing ship would make sail. The state of the wind and weather, is the first thing to be considered. If it blows fresh, it will be prudent for the steam vessel to use no more steam than will just enable her to keep sight of the chase, and try to prevent her getting to leeward; as by that she would have a better or indeed only chance of getting away. If the stranger is to windward, she is in the position most advantageous for being chaced; and the best and only rule to be observed, is to keep her on the same line of bearing. The sailing vessel will no doubt make sail, keeping at first a point off the wind, in hopes of drawing the steam vessel into her wake, and by gradually edging off, would make it a long stern chase; but the steam vessel to counteract this, must steer diagonally towards her, and the moment her line of bearing alters, the course must be altered by bearing up or hauling closer; and by means of the Clarence sextant, (described in the 8th Chapter) or by a common sextant and the table of multipliers, the distance can be found, and the time calculated, which, under the existing circumstances it will require to bring the chase alongside, which is a necessary part of duty on account of the expenditure of the fuel.

If a steam vessel, made proof against shot at a distance of 600 yards, attacks a ship of the line, the state of the weather must be considered. If it blows fresh, she must keep to windward, by propelling a few miles, and then keep under sail until the weather will suit; and it is evident, that having chosen her time, she can, by superiority in velocity, obtain her position, and maintain it at the distance required. This position would be under the stern or quarter, and the distance such that the stern chase guns of the ship could make no impression.

Her bow guns being fitted on slides exactly parallel to, and in a line with the keel, or any two established points, her guns might be pointed by means of the helm, so that she could not err; and as every shot must take effect, the consequence would be the destruction or the capture of her opponent; for let the disparity of force be what it may, she may be said to be perfectly helpless. It is impossible either to close or escape, and any attempt to tow off by boats, would only end in the total loss of the boats and their crews, and they would be run down the moment they near enough to be overtaken. In calm weather, the sailing ship could not have the least chance with a steam vessel; and when it is considered that storms and strong breezes only occupy a tenth part of the year, it follows that there are ten chances to one, that the steam vessels will, in that respect have the advantage.

CHAPTER V.

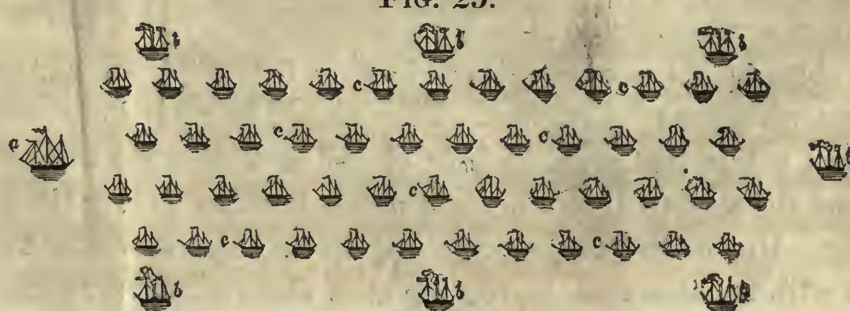
CONVOYS BY STEAM SHIPS.

One of the greatest advantages that Great Britain, as a commercial nation, will reap from the introduction of Steam Navigation, is the protection which it must afford to her commerce. At the first view of the subject, it may appear, that a steam privateer might capture a merchant ship with great facility, by her superiority in velocity, and such is certainly the fact; but on the other hand, it must be taken into consideration, that the merchant ships will be protected by steam vessels, which must render the capture more hazardous, and all efforts to carry off the prize abortive. A convoy of 50 sail, bound to the West Indies, was usually protected by one or two ships of the line or frigates, and two or three small vessels; instead of which, three or four steam vessels will be substituted, and this force will not only be much less expensive, but much more effective in every respect. They will, in the first place, be better able to keep the ships of the convoy within its limits, to tow up bad sailers, or ships that meet with accidents, and to take positions the best adapted for its protection. Admitting that a steam privateer should board and capture a merchant ship of the convoy, it is manifest that she cannot tow off the prize so fast as the protecting steam ship can follow both; and therefore a recapture must be the consequence.

Steam ships for this service, should be from 3 to 400 tons, and should be supplied with powerful engines. They should be rigged like cruizing vessels, and will in that way, be able to sail as well as the body of the convoy, and the steam will not be used unless in chase, during the night, or in a fog. One or two of the protecting steam ships should be kept in readiness with the steam on, to tow up such ships as may be found out off their stations at daylight, or when the weather clears up. It will be of much importance, to have the boilers of the steam vessels which protect convoys, made on the plan which affords the greatest facility in getting up the steam; of which, that of Mr. Gurney appears to be the best. With respect to fuel, that is very easily supplied; as a store ship or two might accompany the convoy. Every ship might be obliged, on taking instructions, to shew that she has a certain quantity of coals on board to supply the steam ships; and those which are towed, should be bound to pay for the coals used in towing them, which would be a stimulus to the masters of merchant ships, to use every endeavour to keep up with the convoy, while it would also induce the owners to employ ships that sail fast, instead of heavy sailers; consequently, what the full built ship gained in stowage, would be lost in the expence of being towed.

If the convoy consisted entirely or partly of East Indiamen, and it was found that the steam ships did not keep up with it under sail, then the fastest sailing Indiamen should take them in tow, until required for service, or a government store ship attached to the steam vessels of a large size, might perform that duty. When the weather is fine and the wind light, the steam vessels of the convoy, can be employed in towing the slowest sailers, or indeed the whole of the convoy ahead; which in crossing the calms near the line, will much more than compensate for the expence. The following diagram represents the manner in which a convoy will sail protected by steam vessels.

Fig. 25.



A (Fig. 25,) the leading ship, *b* the protecting steam vessels, *c* the convoy in the order of sailing.

It will here not be out of place, to point out the best manner of taking ships in tow under various circumstances. *In stormy weather,* if a steam vessel has to send the tow ropes to a large ship which is lying-to for the purpose, she should have a sufficient quantity, say twenty fathoms, of the tow rope coiled in the weather quarter boat. She should then run under the ship's stern a convenient distance, and stop her by the paddles on the lee bow, exactly in the direction that the ship drifts, paying out rope until it is certain that there is sufficient in the boat to reach the ship, when they may pay away as they go, and hand the end on board. If this rope is strong enough to tow the ship, it may be taken in at the hawse hole at once, and when fast, the engine may be set on, and the steam vessel steered so as to get right ahead of the ship before the rope is tort, by which time, the engine should be slowed, and afterwards set on as the ship gathers way, until the whole power is applied. During that time, the rope should not be belayed, but held with a double round turn, by a person stationed to veer or ease it, if too much strain should come upon it. If the ship has to send the end of her tow rope, the steam ship should take up a position on the weather quarter, in the wake of the ship's drift, the tow rope or line should be passed out of the hawse, carried along the weather side, and coiled as before into the quarter boat; and the same directions observed about taking it in. A person should be ready with old canvas to serve the nip before the strain comes on, and a spring from the opposite quarter should be also clapped on, and the rope should not be finally made fast until both parts bear the same strain, and that both ships have had way upon them. The distance from each other, must depend on the state of the sea and the weather, but the nearer they are to each other the better, for the performance of every evolution, and for the supply of fuel to the steam vessel. It will be better also, for the sake of safety, to keep the steam vessel on the weather bow, a very little ; as in that case, both will be more prepared to tack in event of danger, and should any accident happen to the machinery, the ship will more readily be kept clear of the steam ship, and be able to take her in tow until the damage is repaired.

In moderate weather, it is not necessary to lie-to for the purpose of taking a ship in tow, as a steam ship may run alongside of a ship under sail, without any risk of falling on board, and throw a rope to her, by which the tow rope might be hauled on board, and made fast as before. The directions which have already been given are applicable in this case, and also with respect to the steerage of both ships. The commanding officer of a convoy, may make a particular ship's signal to lead, and station himself in a situation best suited to protect or assist.

In calms, the steam ships may take six or eight ships in tow at a time, and carry them on three or four miles an hour; so that if there is one steam ship to every six or eight merchant ships, they need never wait in consequence of calm weather on the line or elsewhere; and ships of a convoy likely to fall on board each other in a calm, can be to a certainty towed away, as indeed all accidents of that nature can be prevented.

It often happens, that merchant ships would make a passage, if they could only get out of the harbour or river in which they are lying. In this case, steam ships can tow them out even against wind and tide, and set them fairly on their voyage; it also happens, that ships in light winds, or calms, are drifted or carried by currents too near the shore or rocks, and are often unavoidably lost. This evil is completely remedied by the introduction of steam, for ships can be towed clear of any danger by a steam ship. The appearance of the weather, may make it desiderable that the convoy should before night, get a better offing; and this can be accomplished by the assistance of steam ships, when it cannot be done otherwise, nor can there be any doubt, that in future, convoys will be often saved by it. Thus, a point may be weathered in one hour by the assistance of steam, which it would take the convoy a day, or even a week, to beat round, to the great loss of the merchants and owners of the ships. In like manner, the ships of a convoy can be towed by steam vessels into a harbour or a situation where they can stop the tide.

EMBARKATION OF TROOPS.

The embarkation of troops will receive great facility by the assistance of steam. If troops are only to be carried off to transports, an immense number may be conveyed on board a steam vessel. On going on board, the arms, baggage, and knapsacks should be taken as they embark, and stowed in a proper place near the centre of the vessel, and the men made to stand close together as they would in their ranks. By this arrangement, much time will be saved, and danger avoided; and the vessel will contain one-third more than are allowed in the usual way, while they will also be able to march out and in, with their arms and knapsacks. If they are to be carried to a considerable distance, only a certain number can come on board, and that is regulated by act of parliament. In this case, also, it is proper that the arms and baggage should be stowed carefully in the place allotted for them: soldiers from sea sickness, want of use to the motion of the ship, are unable to take care of their arms, which might be damaged, without the possibility of their preventing it. When the steam vessel comes alongside of the wharf or the transport, care should be taken that the gang boards are properly fixed, and attended by seamen, before they are allowed to step on them, and they ought to be made to march out and in with regularity, which would prevent confusion and save time. The baggage and arms should be handed in and out by the seamen, or by soldiers accustomed to that kind of duty. Sending troops on an enemies' coast, is the only situation in which soldiers should carry their arms themselves.

Merchant ships should be bound to carry each a certain quantity of coals, and according to the size of the ship a part of these coals should be kept in bags, ready to whip into a boat when wanted, or if the ship is in tow to be swung into her. No ship above 200 tons should be provided with less than 30 strong bags for that purpose, which would much facilitate the work and save time. The method of swinging fuel into the ship is very simple. A five inch hawser with a traveller on it is run through a block at the fore-topmast head of the ship, and the end sent down before all: this end is then sent on board the steam ship, and there made fast to the main or mizen mast. The traveller has a hauling line each way; when the bag is hooked or slung to it the hawser is hauled tort enough to ensure its being kept above the gunwale, the lines are then eased away and hauled in on board the steam boat, the vessels being at their full velocity, but as near each other as they can be brought with safety.

ON LONG VOYAGES BY STEAM SHIPS.

It is believed by those who have not devoted much time and attention to the subject of steam navigation, that it cannot be extended to perform foreign voyages, and it must be confessed that the experiments which have already been made seem rather to confirm than to alter that opinion; but it will be shewn here that the trials which have hitherto been made have not been of such a nature as to justify a decided opinion. The vessel which first crossed the Atlantic made a longer passage than has often been made by sailing vessels, and her engine was only at work 19 hours. The vessel which first went to India had also a long passage, and very little of it was made by the engine; so that these trials should be considered more as relating to sailing than to steam, and those conversant on the subject, who have seen these vessels, pronounced that such attempts were more calculated to bring disrepute than credit, both on themseves and the undertakings. The vessels were miserably bad, both as steam and sailing vessels, although that was not the sole fault, as their engines were, in principle, the very worst that could be employed for such an enterprize, being complicated, easily deranged, taking up much space in the ship, and requiring much fuel. It is not to be wondered at, therefore, that they proved a complete failure, except that they so far gratified the vanity of their owners, in being actually the first which performed these voyages by steam. But to turn to what ought to be the proper steps taken to ensure success, I must first explain the various circumstances which are to be attended to, and the principal one is the nature of the engine. It is manifest that the machinery which is the least complicated, and least liable to derangement, which affords the most power in proportion to the space it occupies, which possesses the least weight, which is most speedily brought into action, and which consumes the least fuel, is that which ought to be adopted for this service. I need scarcely add that the high pressure engine, with tube boilers, has all these advantages, for although it cannot be philosophically argued that the consumption of fuel required in a high pressure engine is less than necessary for a low pressure or condensing engine, still, taking all the circumstances which are hereafter enumerated into consideration *for a service of this nature,* I am justified in saying that it does *actually consume* less fuel in relative proportion to the work it performs. In a vessel of 200 tons the space occupied by the boilers and engines to a 30 horse power, on the plan of Boulton and Watt, and improved by Maudsley on the condensing principle, is 120 tons, or nearly 5-8ths of the whole tonnage, whereas a high pressure engine with a tube boiler of the same power only occupies 50 tons, or one-fourth of the whole tonnage. The comparative weight is as 15 tons is to 60 tons, the high pressure weighing at the rate of five cwt. per horse power, and the low pressure or condensing engine at the rate of one ton per horse power. This difference in tonnage, therefore, and in weight, are decided advantages, which enable the vessel to carry more fuel. On reference to the index, it will be seen that there are above 100 patents taken out for lessening the consumption of fuel, but it is not yet decided which is the best, because there have been no persons established to examine into the various experiments on that important subject. Several compositions have been successfully tried, by which room has been saved but not expence, and they have not been adopted on that account. Another advantage which the high pressure engine and boiler have, is the rapidity with which the steam can be got up. A few minutes, instead of two hours, is all that is requisite; and even with common fuel a ship can "make steam" when it falls calm as speedily as she can make sail when a breeze springs up; and when the engine is no longer of much use, the fire can be instantly reduced or extinguished, even *quicker* than sail can be taken in. When any accident happens to the great boilers which are necessary to low pressure engines, the machinery is rendered useless for many hours, for the very process of cooling and re-heating the boilers, and the water they contain, is an operation of three hours at least, whereas if a tube should burst, or be damaged, it would be only the affair of a few minutes to replace it, and set the engine to work again. The objections, with regard to the safety of the high pressure engine, which consisted entirely in the danger of explosion, are completely done away with by this invention, which is already fully explained in the Chapter on Improvements: it therefore need not be longer dwelt upon, while it may be considered as a decided advantage.

The next circumstance to be considered is the size or capacity of the ship. This must be suited to the length of the voyage she has to perform, and the climate in which she is employed; but in all cases of a foreign voyage the vessel must be capable of stowing a considerable quantity of fuel, and consequently her depth of hold must be proportionally greater.

Although the velocity may be somewhat diminished by this necessary detriment, still there are advantages fully equivalent, particularly where the vessel is propelling against a head sea, for her additional weight will enable her often to overcome its effects, when a lighter and faster sailing vessel could not. An average must be taken of the number of hours it is probable the engine will be at work, until a fresh supply of fuel can be obtained, and compared with the quantity of fuel on board. Those portions of the passage where the engine will be most needful should be marked out, and its power applied accordingly; and it will be found, even in the present state of things, that a voyage either to the East or West Indies, can be performed so as to be comparatively advantageous in every respect: but as the equipment must vary with the size of the vessel, the time of year, and length of the voyage, it is impossible to give any description of it that would be of general use, and in like manner must the rigging be suited to other circumstances. The paddle wheels are the next consideration, and many contrivances have been fallen upon by various inventors, both for security and power, but it does not appear that they are easily injured, although much exposed; for instance, those in the James Watt, (see frontispiece) were exposed and in action the whole of that gale which did so much damage to the breakwater at Plymouth, and they met with no injury. It should also be observed that they are very easily repaired; the arms and circles being made of wrought iron, can be restored to their shape even if almost bent together, by means of jack screws and screw chains, which should always be kept on board for the purpose; the paddle boards are so easily replaced that the loss of one is only the detention of a few minutes. It may not here be out of place to mention that there are several inventions under experiment, which bid fair to do away with every objection respecting paddles, but the patents not yet being secured, I am not at liberty to give a minute description of them. Mr. Costigen has invented a self-revolving paddle, the model of which I have seen, and which I think will be an advantage in many cases. Colonel Macirone has invented propelling machinery, which acts entirely under water, but this I have not seen. Mr. Robertson, of Liverpool, has, from the account I have seen of the experiments made, brought out a method of propelling ships by submerged machinery, which promises the greatest advantages in long voyages, as it will in all times assist the ship in her progress instead of preventing it, and the power of the engine will not be required, except in calms or adverse winds. The experiment will be tried, and the question put to the test this summer.

Finally, it is necessary in long voyages to calculate the number of hours that the engine will be required, and fix on the place where a supply of fuel is to be obtained accordingly. The ships and machinery being suited for the purpose, there can be no doubt that for cargoes of great value, despatches, and passengers, they will supersede every other kind of conveyance.

CHAPTER VI.

THE DEFENCE OF THE NATION AND ITS COLONIES, BY STEAM SHIPS.

THIS subject, which is of more importance to Great Britain than any other, having been particularly alluded to in the introduction, it remains but to point out the manner in which it is to be carried into effect. The steam vessels intended for this service, will comprise every class, and the size and equipment will be suited to the station on which they are to be employed. No part of the coast must be left without them, and harbours must be constructed in every place where it is possible for them to take shelter. The bank to the eastward of Dungeness, for example, might be raised above water, and made an excellent harbour in the place where it may one day be most wanted. Thus, also, Newhaven might be improved; and, indeed, break-waters may be made on various places of the coast. The Downs, it is plain, will no longer be a safe anchorage for ships that cannot protect themselves: and here therefore, some steam vessels of the first class must be stationed; those of the second class being kept in the dry harbours, in a situation ready to take advantage of the tide at the moment it rises, so as to float them. Where a harbour for steam vessels cannot be made, it will be absolutely necessary to erect martello towers to protect the coast.

The difficulty of invading England, will however be much increased by this system, and our shores will assuredly be far safer under the protection of steam vessels; and if these are constructed for the protection of the coasts of Sussex and Kent, so as to be proof against shot, the invading enemy must do the same, or their vessels would be instantly destroyed. But if their vessels are made proof against shot, they are not only rendered more expensive, and of a greater draught of water, but they become unfit to carry troops; since it would take all the money in Europe to fit out a steam fleet sufficiently large to carry 100,000 men, while they would occupy such a space of coast, as would render the landing impracticable.

On the other hand, if they employ transports as formerly, they will be all sunk and destroyed before they are half seas over, by our shot-proof steam vessels. Again, our force can be concentrated, independently of wind and tide; and before any body of men, capable of maintaining a footing on British ground could be landed, the whole force of England could be brought against them. The transports which would be necessary to contain the troops for an invasion, must be towed by steam vessels, which would impede their progress, and prevent their arrangement for attack and defence; and as the transports themselves would be little more than marks for our steam ships to fire at, they would consequently share the fate of the Spanish Armada. The greater the distance that these transports would have to be towed, the greater must be the difficulty in executing the expedition; and as for landing a large body of troops on an open coast in one night, we know that to be impossible.

An invasion of England must be attempted on the coasts of Kent or Sussex; and it is there that the greatest attention must be paid to the protection of our coast, both on the land and the sea. Steam vessels the best suited for the harbours which are and which must be made on that coast, must therefore be constructed, both for the protection of our nation and our commerce; and that both the nation and its commerce will by these means be more effectually and less expensively protected than ever they have been yet, there cannot be the shadow of a doubt. On the Portsmouth and Plymouth stations, the steam vessels will be of the first and second class, except those which are stationed for the protection of small dry harbours, which will not admit of a large vessel. The coast to the westward, and that of Ireland, will also be protected in the same manner; while to the larger steam ships, store ships for carrying fuel should be attached; these being kept in constant readiness, and care also being taken that they are good sailers.

Depots of stores and fuel should be kept in all the colonies, to supply the protecting steam ships. The colonies will also, and in the same manner, be far better protected; for even the windward passage to Jamaica, will, by the help of steam ships, be always attainable. Henceforth, therefore, should this system take root and spread, none of our Jamaica-men need pass through the Gulf Stream, and the merchants would be gainers by keeping a steam ship or two, for the express purpose of towing their ships through the windward passage, as it would often make a month difference in the length of the passage; besides that the risk of being wrecked or plundered would be entirely done away. To the East India Company, the introduction of Steam Navigation is of the highest importance; since the monsoons, the currents, and the calms, are at once set at defiance. The navigation of the Red Sea and the Persian Gulph, with the channels through the various straits in the passages to China, will be thus also rendered safe and easy: and this new art should therefore be cultivated by the officers of their marine in particular, from the protection which it will afford to the coasting or country trade. The security thus gained against pirates and privateers, is alone sufficient to warrant its encouragement; but to that may be added the facility it gives their government, of transporting the disposable force and artillery to the point threatened by a rebellious native prince; and the effect of its power in actual service, has already been proved, in the share which it took in the late Burmese war. Steam ships in the Hoogly and other rivers must be also very conducive to the safety of the navigation, and to expedition in carrying on the trade, in assisting ships in distress, and in carrying to an anchorage of safety, ships which could not otherwise reach it. But it is to the Bombay Marine Service, that this invention is peculiarly advantageous; because rivers, creeks, and harbours, can be protected aud explored with positive certainty, and piracy can by these powerful means be readily and effectually quelled.

The communication with England, after the affairs with the Ottoman Porte have been amicably settled, can be carried on through the Red Sea, Mediterranean, &c. in about one half of the time that it could be done in any other way. A set of vessels of the largest class, must be stationed between Falmouth, or Portsmouth and Gibraltar; a set of the second class between Gibraltar and El Arish, or at whatever point in Egypt it may be found most advisable to establish a steam vessel harbour. From thence to Suez, the passengers baggage, &c. should be carried by a flying railway, which would be the most effective and durable, and in the end, the least expensive mode of conveyance. From Suez to Mocha, the voyage may be continued in steam vessels of the second class, and from thence to various parts of India in vessels of the first and second class.

ADVANTAGES OF STEAM SHIPS TO THE NATION.

If war is still carried on by sailing ships, the advantages which the assistance of steam ships will give must generally decide the victory.

The loss of masts will be no longer of consequence, since the ship can be towed into action, just as well after they are gone as before, and her broadside placed to the enemy. It is plain, therefore, that when any ship is dismasted, the victory must belong to those, whose steam vessels are still in a state to assist; and it will then be a battle between the steam vessels, to decide which shall carry off the whole: so that the advantage in every future naval battle, will entirely or eventually depend on the steam ships which accompany the fleet; and the same may be said of two single ships. If both are dismasted, like the Eurotas and the Clorinde, one steam vessel could easily sink, destroy, or capture both, even if she had only one gun.

It may also be remarked, that the nation will be defended much more effectually, at one half of the expence, with one third of the number of seamen, with one half the officers of high rank, double the number of captains, treble the number of lieutenants, and four times the number of inferior officers than by the present system.

The coasting commerce will be more completely protected from privateers, and more expeditiously and advantageously carried on, to the satisfaction of every one concerned, than by the present system.

The foreign commerce will be carried on with a certainty never before known; there will be no delays of convoys for a fair wind or by a calm, and the ships cannot be blocked up in a harbour by a foul wind. They will be kept strictly within the limits; and no privateer will approach with any hope of carrying off a prize.

Troops will be embarked, and conveyed from one part of the kingdom to another, with an expedition never before known, and at one half of the expence, together with more comfort; carrying further, every thing which belong to them, such as arms, ammunition, baggage, women and children.

Artillery and cavalry can be in like manner shifted from one part of the kingdom to another, quicker than is possible by any other mode.

The transportation of troops between the islands and settlements in foreign colonies, will be facilitated in a manner which bids defiance to the trade or periodical winds, and to the tides and currents; this being at present often impracticable, on account of their influence.

The advantages of steam ships employed as post office packets, has been already fully established, and will no doubt materially increase the revenue. Passengers can now calculate with certainty when they will be at their destination, and merchants when they will have their returns, letters, bills, &c. to meet their engagements; and, with respect to both safety and comfort, there is no comparison.

The advantages of steam ships as surveying vessels are equally manifest; since more actual work, particularly in a stasimetric survey, can be performed in one day, than can often be done in a month by a sailing surveying vessel, and since the men employed can always be comfortable, have their proper rest and food, and return to an anchorage independently of wind and tide. They can also stop their velocity in coming into shoal water much better than a sailing vessel can, and also regulate their rate of sailing. If they touch or stick on the ground, they have a far better chance of getting off, and they are far more secure from natives or barbarians.

The advantage of steam vessels in carrying dispatches is so obvious, that it is almost unnecessary to mention it. What admiral or commanding officer would send his dispatches by a sailing vessel if he could get a steam ship?

The advantages of steam ships in suppressing piracy is of the utmost importance; a *steam pirate* could not be easily fitted out without considerable alarm, and all others must instantly be destroyed by the protecting steam ships.

The advantages of steam ships in supplying and equalizing the markets are most beneficial to the public. There can now be no famine; as steam vessels can bring food from the remotest part of the kingdom, and from the neighbouring countries, with such certainty and speed that no serious consequences could accrue from a scarcity of corn or other necessary of life. In the supply of fuel also, the steam vessel is a most useful invention; since coals can no longer be locked up in Newcastle by an easterly wind, and as the colliers can be towed by the half dozen out of Shields and the several ports on the East Coast of Great Britain, whence, after having been towed out to sea about a mile, they have a fair wind up to London Bridge.

The advantages of thus supplying the metropolis with fish, must be acknowledged by all; and although it has been said by the fishermen that steam vessels frightened away the fish, this opinion is without foundation.

The advantages of steam ships as yachts are so clear, that it is a wonder any amateur could even construct a sailing yacht, when every object he requires is so much better attained in a steam ship than in any other. This neglect is only to be accounted for by the fact that their owners are entirely ignorant of the subject. As soon as it is positively known that by some of the late improvements in the boiler, no accident, such as explosion, likely to be attended with fatal consequences, can take place, they will certainly supersede all pleasure vessels and yachts above 200 tons, and the royal yachts should be all steam ships.

But these advantages in time of war will not be attained, unless we take the lead in this somewhat new art. Inspectors of steam vessels should be appointed, who are well acquainted with the principles, nature, and practice of the steam engine, who are also thorough bred seamen, who are capable of judging of the various inventions which come before the public, and who are not interested in any way, directly or indirectly, with any of the parties. Their duty should be to inspect all steam ships, and report to government their qualifications and fitness to obtain a licence to carry goods or passengers, to regulate their crews, and determine disputes. These inspectors should attend all experiments made on the steam engine, and sit as a committee quarterly, to determine what inventions are, and are not, worthy the encouragement of government and the public. It must always be kept in mind that the engineers who are employed to make these engines have more relative profit in making one of the expensive than of the cheap kind, and it is therefore their interest to recommend them, and to set their faces against simplification and improvement. That many inventions of a most important nature are kept back by these means, especially if the inventor has not capital to bring it fairly before the public, there is no doubt; and as examples of this fact, I will mention the inventions of Mr. Goldsworthy Gurney and Mr. Costigin, and many others. The high pressure engine is made perfectly safe by the application of Mr. Gurney's boiler, and no one conversant on the subject will deny that this principle is the most applicable to naval purposes; as it is much less expensive and far less liable to injury, takes up only half the room, is one tenth of the weight, and consumes under all the circumstances, much less fuel. Yet it has never made its way in this country, although it has in France; merely because it has never had a fair trial, and the inventor has not capital to bring it forward against the opinion of those whose interest it is to keep up the low pressure engine, as being the most profitable to the maker. The high pressure engine will however, and, in case of war, must supersede the condensing engine, and the attention of government will no doubt be turned to that important point. For the improvements I must refer the reader to the 8th Chapter, and the appendix, where he will find copies or extracts of the specifications of the patents, with remarks on them.

CHAPTER VII.

ON THE IMPORTANCE OF ESTABLISHING REGULATIONS.

Within these few years the number of steam vessels employed in various ways on the seas and rivers which surround Great Britain, has increased to nearly a thousand; and as there are yet no established regulations, either for their equipment, appointment, or management, it is to this and not to any defect in the science, that we must attribute the many accidents which have proved fatal already to hundreds. The steam vessels are generally the property of individuals who hold an interest in them by shares, and this business is usually conducted by a committee. This body of persons has the power of appointing not only the captain, mate, and pilot, but also the seamen; and whatever may be their conduct, they cannot be displaced by their captain from their situation, which they hold independent of him, by the interest they or their friends have in the committee, and presuming on their independence they are therefore under no sort of order or discipline, whence their duty is not performed as it should be for the good of the vessel and for the safety of the passengers, while, further, the captain cannot complain of them, because by doing so he may lose his own place. Another evil, of a still more serious nature, calls most loudly for a remedy, and that is the defective state of the machinery, which is never inspected by independent and disinterested persons, and is therefore permitted to go to the last, or until some accidents take place, which obliges it to be repaired after it has brought the whole system into disrepute. It is the interference of government alone, which can put a stop to this; in the first place, by appointing an Inspector General, and Inspectors under him, for England, Scotland, and Ireland, as well as at each of the great Ports. These officers should be well qualified, and conversant with the principles, nature, and construction of the steam engine; they should also be qualified to examine the commanders, mates, and men, touching their knowledge of Naval Tactics, and in the various duties which they have undertaken. They should be qualified to examine the engineers and their men, respecting their professional knowledge; and it should also be their duty to examine the ship or vessel, and every part of the machinery, and to report whether or not the lives of His Majesty's subjects would be safe in embarking in them; they should likewise see that the boilers and machinery are so placed, that they can be easily examined; and they should be invested with the power of correcting all these evils, of hearing and deciding on the complaints of the commanders, mates, engineers, men, and passengers, and to regulate their numbers. The following regulations are proposed.

I. The commander of every steam vessel, to be skilled in the art of navigation in general, as well as in that peculiar to steam ships.

II. The mates and pilots to be skilled in seamanship, in steering, and acquainted with the art of navigation.

III. The seamen to be men brought up to the sea, and not landsmen: they must have been either four years at sea, or in a sailing or steam vessel on rivers.

IV. The engineers to be able to pass their examination on the principles and nature of the engine, and also on its practice as applied to ships.

V. The stokers to be men brought up to that calling; they may be landsmen.

VI. The servants to be persons qualified for that station.

VII. The engine and boiler to be placed in such a situation and manner that they can be thoroughly examined; they are to be cleaned at the end of every passage or time they are used, and before the fire is again lighted, they are to be inspected by the commander, or proper person appointed to inspect them, and the report of their state inserted in a book kept for that purpose.

VIII. The safety valve, whether the engine is one of high or low pressure, is to be made so that the engineer has the power of raising half the weight which is upon it, the instant that he stops the engine, and he is not to depend on one of his men loading or unloading it, and it is to be securely enclosed in a case, so that no one can get at it.

IX. The engine room never to be left, without one of the engineers being on duty there while the steam is up; and when the word or signal of attention is given, he is to keep the levers in his hands, as also at night, in a fog, or in a river, ready to slow or to back the engine as required: and he is not on any account to leave his post, for any purpose whatever, until relieved.

X. The captain, officer, or pilot, (if in pilot water) is to have the entire direction of the course, velocity, and of giving orders or signals to the engineer; and the following words of command, and signs or signals are established.

ATTENTION.

To be answered by a nod or inclination of the head.

1st. SET ON, *or both hands raised as high as the head.* The steam is then to be set on, and the engine set in motion.

b

2nd. Slow the Engine. *Right hand raised as high as the face, and opposite or above it.* The engine is then to be slowed, and the weight on the safety valve raised by the engineer, who is to keep the lever in his hand.

c

3rd. Reverse the Engine. *Left hand up to the face, but not above it.* The engineer is then by reversing the lever, to cause the paddle wheels to back or revolve, in giving the direction of a stern board.

d

4th. Stop the Engine. *Both hands across the chest.* The engine is then to be stopped, and the safety valve lifted. N. B. The signals or signs are to be repeated by an intermediate person, if the engineer cannot see the cap.

e

5th. Starboard. *The right hand extended at full length.* The helm is then to be put to starboard, and the signal is to be repeated by the look-out men, to any ship that is seen approaching.

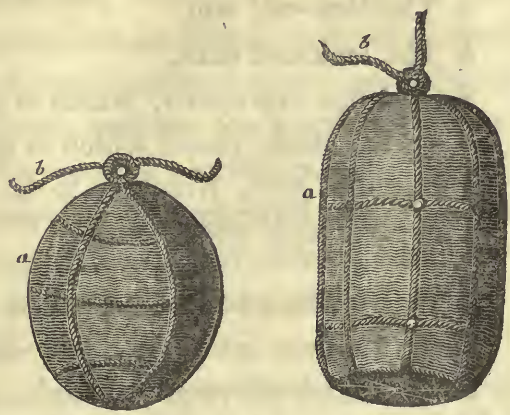
f

6th. Port. *The left hand extended at full length.* The helm is then to be put to port, and the signal to be repeated by the look-out men, to any vessel seen approaching.

XI. The stokers or firemen, are to be kept constantly at their own duty; and they are not to be employed on any other, except in cases of emergency: they are to be relieved every two hours.

N. B. It is recommended that they should be allowed double or extra allowance of beer or other beverage.

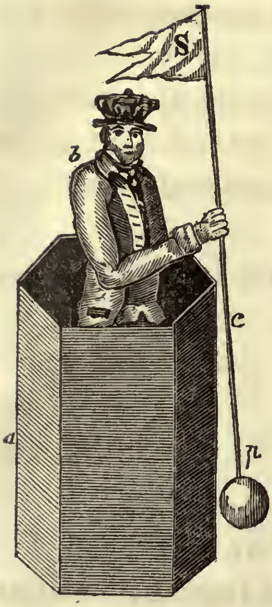
XII. Every steam vessel is to carry over each bow, two cork fenders, such as described on the margin.



a a the two fenders, *b b* the ropes by which they are suspended. The size to be regulated by the inspector, and the situation fixed by him, for the purpose of lessening the effect of collision, should it unavoidably take place; and every steam ship is to be provided with two spare ones, to place where they may be required.

XIII. The helmsman is not to be spoken to or interfered with, by any person but the officer in charge of the deck.

XIV. Every steam vessel shall have a platform known by the name of a top-gallant forecastle, on which are to be placed the two look-out men, who are to report every vessel that is seen, in whatever direction it may be, and give timely warning on the approach of small boats; or they are to have a look-out tent, such as here described: the look-out man having in his hand a pole, which has a flag on one end, and a ball on the other, with which he is to repeat the signs and orders of the commander.



EXPLANATION.

a The look-out tent.
b The look-out man.
S Signifies *starboard,* which is to be repeated by by the steam vessel which is approaching.
p Signifies *port,* which is to be repeated by the approaching steam vessel.

N. B. The tent to be elevated 3 feet above the deck, the man enters by a trap-door in the bottom, on which he afterwards stands, and no person is allowed to speak to him but the officer in command or charge of the vessel.

XV. All steam ships and vessels, meeting another steam ship or vessel sailing or propelling in the opposite direction, shall put the helm to *starboard,* passing with their *starboard sides* to each other, they shall slow their engines when at the distance of one hundred yards, unless they can pass at the distance of fifty yards of each other.

XVI. All steam vessels passing within hail of each other, to slow their engines, until fairly past; and steam vessels shall on meeting or passing sailing vessels, always pass astern of them.

XVII. When a steam ship or vessel overtakes another, in any narrow channel or river, the steam vessel that is overtaken, shall keep to the larboard side of the river, and slow her engine, when at the distance of forty feet, until the other has passed.

XVIII. When in a river, no sail shall be carried on the bowsprit.

XIX. The engine shall always be slowed when a boat is coming alongside, just in time to let the boat come to the gangway when she has lost her way.

XX. Every steam ship or vessel to carry a boat over the stern; if above 200 tons, one boat on the quarter; if 300 tons, a boat on each quarter, besides the stern boat: the size and capacity of these to be regulated by the inspector.

XXI. Every steam ship to have two life buoys on the quarter or stern, ready to slip or cut away, if required.

XXII. Drunkeness to be punished: first offence, by fine; second, by dismissal.

XXIII. The helm not to be entrusted to a passenger, or other person, not duly qualified.

NIGHT.

I. During the night, every steam ship or vessel shall carry a light at her foremast head, or if she has no mast, on a pole 12 feet above the deck, in such a position as it can be best seen. Steam ships or vessels are also to have another light ready, on meeting another vessel, to shew on the starboard bow.

II. No steam ship or vessel, is to carry any sail on the bowsprit, during the night.

III. Two look-out men are to be stationed on each bow, who are to report every sail and object that is seen ahead, or anywhere else.

IV. All orders, regulations, and words of command which are established for the day, shall apply to the night also.

FOG.

I. All steam vessels are to propel in a fog, without having any of the lower sails set, nor any of the topsails, unless necessary to steady the motion of the ship.

II. In a river or narrow channel, no steam ship or vessel is to have a velocity of more than four miles an hour, during a fog or thick weather.

III. In a fog, all steam ships or vessel coming down a river, or if at open sea, steering on any point of the compass which has East in it, including the North Point, are to sound bells for one minute, with an interval of two minutes; and all steam ships or vessels going up a river, or if at sea, steering on any point of the compass which has West in it, including the South Point, to sound drums for two minutes, with an interval of one; and the former is to slow her engine, to listen for two minutes at the end of every fifteen minutes, and the latter is to slow her engine for one minute in every twenty minutes. The size or power of the bells and drums, to be regulated by the inspector.

IV. When absolutely necessary to increase the velocity in a fog to five miles an hour, a gun is to be fired every half hour, and immediately afterwards, muskets in succession, one for every mile above five; at ten miles, two guns are to be fired, and for every mile above ten, a musket in succession.

V. In a fog, steam ships, the moment a gun is fired, are to slow the engine, and by listening for muskets, ascertain how many miles the vessel is going; and by bells or drums whether the vessel is going East or West. When a ship hears the bells of another, she is to fire two muskets, and if she hears drums one musket.

VI. The same regulations respecting the engineer, the fenders, and the words of command during the night, are also applicable to a fog.

VII. When steam vessels steer across a river, the article III. respecting the compass is to be observed.

The following table is calculated to shew the quality and number of the officers and men composing the crews of steam vessels of war of each class, supposing them to have long guns and carronades, mounted only in proportion to the number of men.

Class.	Tonnage.	Power of Engine.	Captains.	Commanders.	Lieutenants.	Masters.	2nd Masters	Mates and Midshipmen.	Warrant Officers.	PettyOfficers.	Seamen.	Marines.	Servants.	Engineers.	Stokers.	Coal Trimmers.	Boys.	Surgeon.	Assistant Surgeon.	Purser.	Clerk.	Total.
1	2000	400	1	“	4	1	“	7	3	3	25	15	4	3	9	6	4	1	1	1	1	94
2	1500	300	1	“	3	1	“	6	3	6	15	10	3	3	6	4	3	1	“	1	“	65
3	1000	200	“	1	2	1	“	4	3	4	12	8	3	2	5	4	2	“	1	“	1	53
4	500	150	“	1	1	1	“	3	2	3	9	7	2	2	4	3	2	“	1	“	1	42
5	200	100	“	“	1	“	1	2	2	2	8	5	2	2	3	2	2	“	1	“	1	34
6	200	60	“	“	1	“	1	1	2	1	8	“	1	2	2	2	1	“	“	“	1	23

We shall now proceed to shew by the following table, the number of each class which would be necessary to man a flotilla of 3,000 steam vessels of war, in case it should be found advisable, (as in all probability it will) to substitute them for 1,000 sail of men of war, which were found necessary for the protection of the nation and commerce during the last war. The steam vessels are proportioned to correspond with the respective classes which were then in the Royal Navy.

Class.	Number of SteamVessels	Captains.	Commanders.	Lieutenants.	Masters.	2d Masters.	Mates and Midshipmen.	Warrant Officers.	PettyOfficers.	Seamen.	Marines and Officers.	Servants, Landsmen.	Engineers.	Stokers.	Coal Trimmers.	Boys.	Surgeon.	Assistant Surgeon.	Pursers.	Clerks.	Total, Men.
1	200	200	“	800	200	“	1400	600	1600	5000	3000	800	600	1800	1200	800	200	200	200	200	14800
2	300	300	“	900	300	“	1200	900	1800	4500	3000	900	600	1800	1200	1500	300	“	300	300	20400
3	500	“	500	1000	500	“	2000	1500	2000	6000	4000	1500	1000	2500	1500	1000	“	500	500	“	26000
4	1000	“	1000	Sub. L. 1000	“	1000	3000	3000	3000	9000	7000	2000	2000	4000	2000	2000	“	1000	“	1000	42000
5	1000	“	“	Sub. L. 1000	“	1000	1000	2500	2000	8000	“	2000	1000	2500	1000	1000	“	1000	“	1000	25000
	3000	500	1500	4700	1000	2000	9200	8500	8400	32500	17000	7200	5000	12600	6900	6000	500	2700	1000	2500	140700 S. & M.

By the above table, it is manifest that the proportion of officers required for the defence of the nation on this system, is much greater, and that of the seamen much less, than on the system carried on last war; it will most probably be found necessary to re-establish the rank of sub-lieutenant, or to give passed mates a certain rank equal to that of a lieutenant in the army, in order to give them that authority which is necessary to the responsibility they will have, as second, and in small vessels as first in command. Before we proceed to estimate the comparative expence, it is necessary most distinctly and unequivocally to point out, that the present system of equipping steam ships with low pressure or condensing engines, is one which is ruinous to every person, except to the manufacturers, whose interest however it is to advise all their customers to continue the use of that cumbersome and expensive machine, as the high pressure engine would certainly be to them less productive: but the advantages in the latter are so decided, and so manifest to those who have studied the subject, that we have no hesitation in declaring, that to continue to use the former any longer is extravagance and folly, and that to put them into a ship of war is absurd. The only plea that could ever be adduced as an excuse for not using the high pressure engine, was the danger of explosion; but that has been completely remedied, by generating the steam in tubes, which are now brought to such perfection, as to set that question at rest. In the following estimate, therefore, let it be understood that the engines are all those of high pressure, which will and must supersede every other, and with tube boilers.* An average may be taken of all the 3,000 steam vessels, including the engine at £10,000 each, which will make £30,000,000, and which is not above one-fourth of what the late navy cost. The materials for building and equipping are all found within our

* The tubes of the boilers should always be proved by water, in the same manner as a gun barrel is proved, before they are allowed to enter a ship.

own kingdom. There can be no better wood than larch for this purpose, as being the most buoyant, it displaces the least water, while we have iron and coals in abundance. In manning the steam ships, so few seamen are required, that there will never be any occasion for impressment, but senior officers and engineers will be in great demand; indeed it is absolutely necessary that a school should be established for the instruction of the rising generation of these classes; several captains and lieutenants who have studied the subject, should be employed to instruct those who have no opportunity of obtaining the information, which is absolutely necessary.

The following table is calculated to shew the crews which are proper for steam vessels employed in carrying goods and passengers, and which each should be obliged to have on board.

Class.	Tonnage.	Horse Power Engine.	Captain.	Mate.	Pilot & Mates.	Servants.	Female Servants.	Seamen.	Engineers.	Stokers.	Coal Trimmers.	Carpenters.	Total.
1	1000	200	1	1	1	8	2	14	2	6	5	2	42
2	500	150	1	1	1	5	2	8	2	5	4	2	31
3	300	100	1	1	1	4	1	6	2	4	3	1	24
4	200	60 to 80	1	1	1	3	1	4	2	2	2	1	18
5	100	30 to 50	1	"	1	2	"	3	2	2	1	1	13
6	Boats.	under 30	1	"	1	1	"	2	1	1	1	"	8

The above calculation is adapted to both low and high pressure engines, but there can be no doubt that in a few years, the low pressure engine, even in these vessels, will be considered a specimen of the folly instead of the wisdom of the inventors, and certainly an imposition on the owners.

The following are the dimensions of the United Kingdom steam ship, built in 1826, by Mr. Robert Steel, Greenock, and of the Majestic, built by John Scott, Esq. of Greenock, 1821.

Engines both by Napier and Co. Glasgow.

Name.	Length on Deck.	Length for Tonnage.	Length of Keel.	Extreme Breadth.	Breadth between Paddles	Depth of Hold.	From the up. Deck of Keel.	3 ft. of Water fore and aft.	3 ft. of Water with Coals.	Nature of the Engine.	Power of the Engine.	Tons by Law.	Actual Ton. besides Eng.	Number of Berths.	Main mast.	Main yard.	Main topmast.	Fore mast.	Fore yard.	Fore topmast.	Mizen mast.	Quantity of Coals stowed.	Coals used per hour.	Crew.	Miles per hour velocity.	Against a Gale.
	ft.		ft.	ft. in.	ft. in.	ft.	ft.	ft. in.	ft in.													Ton	Cwt	1class	calm	
United Kingdom	175		147	45 6		12	18	9 6 f. 10 0 a.	11 0 f. 12 6 a.	Low Pres.	200	561	350	160	81 6 1 8		52 0 1 0	76 0 1 8	72 0 1 2	50 0 1 2	60 0 1 5	170	17	42	11	3
Majestic	144		125	39	22 6	11	16	7 0 f. 8 0 a.	8 6 f. 9 9 a.	Low Pres.	100	270	254	76	68 0 1 4		45 0 0 9	60 0 1 4	62 0 0 11	40 0 0 9	56 0 0 1	100	15	2class 31.	10	3

These vessels are said to be the fastest packets that have yet been built; but the Thames, Shannon, Town of Drogheda and the Lightning, have excellent qualities as sea boats, and are fit to make headway against a gale, however severe; and certainly long after a sailing vessel must drift at its mercy. These dimensions should be attended to, and proper officers sent on board of them, to ascertain their qualities, and make official reports on the same, as also on board any or all other vessels; by which means the kind of vessel proper for peculiar services or stations, would be fully ascertained.

CHAPTER VIII.

OF THE RECENT IMPROVEMENTS IN THE STEAM ENGINE.

Having in the first chapter given a general and comprehensive account of the Steam Engine, and traced it through its several forms and states of improvement, as they exist and are known up to the present time, I shall now resume the subject again to speak of the more recent improvements which have been suggested, and in some instances carried into effect, though not to a sufficient extent to have rendered them generally known to the public. Among these, the most conspicuous of them are the steam engines of Mr. Perkins, and Mr. Gurney; the gas vacuum engine of Mr. Brown, and the carbonic acid gas engine of Mr. Brunel.

Mr. Perkins was one of the first that attempted the contruction of a steam engine on principles essentially different from any that had preceded him; and for a time, he certainly raised the most extraordinary hopes of success in the public mind. He carried his experiments upon high pressure steam to a much greater extent than any one had dared to do before him, and has broached some very singular notions with respect to steam. One of these is that the elastic force of steam is not infinite, with increase of heat, but that it is limited to the amount of 56,000 lbs. on the square inch, and consequently, if the vessel is sufficiently strong to resist this pressure, no fire that can be applied to it will be capable of producing steam that will overcome or burst the vessel, and that in such a vessel water may even be made red hot, without any danger of explosion. Mr. Perkins has also endeavoured to establish an hypothesis, that as water is a nearly inelastic fluid, while steam is a highly elastic one, there can be no danger of water ever bursting a vessel that contains it, unless that water be permitted to be converted into steam; and consequently, if a vessel is so completely filled with water as to allow no space for steam to form, such vessel can never burst, notwithstanding it should be heated to any degree. On this principle, Mr. Perkins constructed his engine, or rather his boiler, which he calls a *steam generator;* for it does not appear that there is any thing novel in his engine, it being merely a metallic piston working in a bored cylinder, and operated upon by steam of enormous power, in the same way that steam of less force was formerly made to act in the engine of Trevithick.

Mr. Perkins's steam generator consisted in the first instance of a small wrought iron cylinder of immense strength, which was completely filled with water; it had a conical valve of very small dimensions on its top, and this valve, which was very heavily laden, up to from 500 to 800 lbs. on the square inch, was confined within the pipe that was to supply the cylinder with steam. A very small and powerful forcing pump, capable of supplying but a minute quantity of water at each stroke, worked into the bottom of the generator, which, when filled with water until it could contain no more, was violently heated; but according to his hypothesis, no steam could be produced. When so heated, the forcing pump was worked, and it drove a few drops of water into the generator, which could not enter, without at the same time expelling an equal quantity of water in a nearly red hot state, from the upper loaded valve; and as soon as this heated water was released from the pressure of the metal cylinder, it instantly *flashed* into steam, within the steam pipe, (to use Mr. Perkins's own term) and was ready to act upon the piston, like steam produced in the ordinary way. In this manner, Mr. Perkins has produced steam, having a force of 800 atmospheres, or equal to 12,000 lbs. on the square inch, and he contends that this process is not only much more safe, but at the same time more economical than any other method of producing steam. Mr. Perkins not only applied the powerful steam that he produced in this way to the working of steam engines, but to the purpose of discharging balls and shells from steam guns, which he effected with astonishing force and rapidity, completely surpassing what could be done by gunpowder; and if this powerful steam could at all times be instantly commanded, it would furnish a most terrific engine of warfare. Mr. Perkins has since substituted a numerous series of very thick and strong cast iron tubes of small bore, all having connection with each other, in place of the former cylindrical shape of his generator; but as his machinery is of necessity very strong and heavy, and the heat required to work it very great, this form of engine does not appear to be well calculated for maritime purposes, and I shall therefore make no further observations upon it.*

The tube boiler of Mr. Goldsworthy Gurney, whose name is well known in the scientific world, is of a very different description, and as I think this boiler will be found particularly applicable to naval purposes, I shall enter into its history and description more fully than I should otherwise be warranted in doing.

Although the system of generating steam in tubes had been repeatedly tried, and as often abandoned as hopeless by many of our best engineers, Mr. Gurney, from a conviction that no other mode of generating steam could be applied to locomotion on land, was led to study the reasons why former attempts had failed. From previous experiment, it had been found that when steam was formed in a less area than 30 square inches, it could not separate itself effectually from the water, because if it rose to the surface, or passed along a channel of a smaller area than this, it carried

* See Appendix.

the water with it, leaving the surfaces of the containing vessel dry; in consequence of which it soon became red hot; thus causing a rapid oxicitation of the metal, a formation of hydrogen gas, and a total want of effective steam. But this was not the only difficulty, for the hydrogen gas, formed from the hot portions of water in the tubes, carries with it so much heat as to burn and destroy the packings of all the joints either belonging to the pipes or to the working cylinder. It was found in one experiment that lead was melted at the distance of forty feet, by hydrogen formed from water passing through a red hot tube.

The next difficulty arising from this cause was the sudden and unequal expansion of the metal composing the boiler, which invariably destroys all the joints if made in the ordinary manner, *i. e.* packed with lead, rust, or hemp. The next difficulty of much importance seemed to arise from the deposits of earthy concretions, which in a short time fills up the tubes and prevents the entrance of water. Supposing the objections above mentioned to have been removed, another very serious practical objection is occasioned in tube boilers by the effects referred to, namely, that of the water passing away with the steam.

The passage of water with steam into the cylinder invariably chokes the engine, destroys its action, and has even in some cases been known to have occasioned the breaking of the cylinder cover. All these difficulties may however be overcome by effecting a perfect circulation of water through the tubes, produced by the steam itself, and by the separation of the water from the steam after it has left the boiler, in a separate external vessel constructed for the purpose; which arrangement removes all the difficulties, except those deposits of earthy substances arising from the evaporation of earthy water. Mr. Gurney observed, by a close analysis, that almost every earth, or combination of earth found in water under common circumstances, might be dissolved by chlorine, which is cheaply formed by the action of a mixture of sea salt and quick lime, and which may be rendered so soluble as to be blown out at pleasure; the joints he also proposed should be packed with an elastic fire proof substance, which will preserve them sound, even if the boiler by any accident, from defect of pumps, or any of its machinery, should become dry. Mr. Gurney accordingly invented and constructed a boiler on these principles, and its advantages for naval purposes, are manifold and important. They may be thus enumerated.

1st. Safety from explosion; the tubes which are only three inches in circumference, and are made so strong that they will bear a pressure of 1000 lbs. to the inch; the steam separators, junction pipes, and indeed, every part which contains steam, are in proportion, so that high pressure steam can be worked without the least probability of bursting the boiler, or any other explosion; and should it burst, the quantity of water it contains is so small, as to be incapable of doing any mischief.

2nd. The boiler is only one-twentieth of the weight compared to that in use on the principle of Boulton and Watt, and it occupies only one-third of the space.

3rd. The saving in fuel, taking all circumstances into consideration, will be more than one-third.

4th. The steam can be always got up in ten minutes, from lighting the fire, whereas in other boilers, from one to two hours are necessary.

5th. The boilers, and indeed the whole of the apparatus, except the shaft and paddle wheels for propelling, can be placed completely out of the reach of shot, i. e. under the water line.

6th. This boiler is less liable to get out of repair, and when damaged will be much easier repaired than the common boiler. One of its tubes being broken, is of no consequence, as it can be immediately plugged up, when only one thirty-sixth part of the power of that boiler will be lost, or a two-hundredth part of an engine, with six boilers of 80 to 100 horse power; all which has been proved by an experience of near two years, so as to have put the question beyond all doubt, because boilers on this construction, have been in constant use during that period, at his own manufactory near the Regent's Park, as well as at various other places.

Fig. 26.

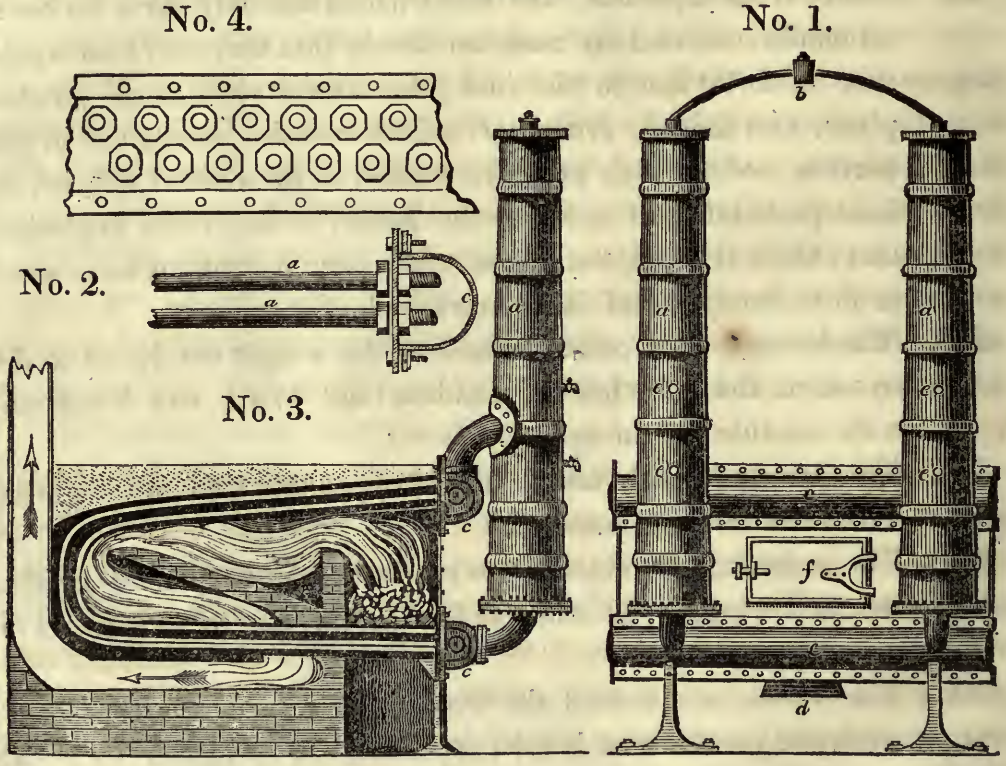
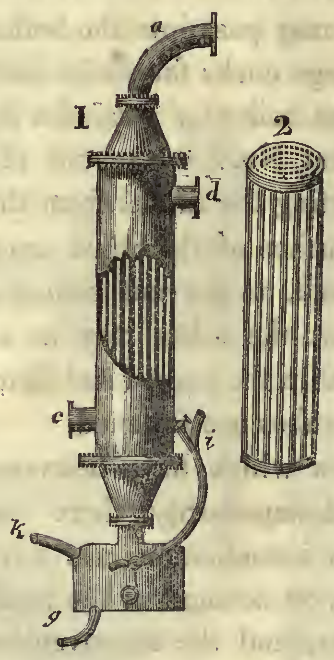


Fig. 26, No. 1, represents a front view of this boiler; *a, a,* are the chambers into which the steam and water are received when generated in the tubes, and are there separated from each other by the steam rising, and the water falling to the bottom; these chambers are therefore called *the sepa-*

rators. *b* is the tube which unites the two separators, on the top of which the safety valve is placed; *c, c,* are the chambers to which the tubes composing the boiler are connected, a side and front section of which are shewn by the two upper figures, and on the left hand, *a a* being the boiler tubes screwed to the flat side of *c*, the chamber and the upper figure shews the disposition of the boiler tubes, in part of that flat side. Into either one of these chambers, the injection pipe of the force pump for feeding the boiler is inserted: *d* is a small well, to receive any extraneous matter, which may pass into the boiler, and can be opened at pleasure; *e, e,* are the guage cocks for steam and water, the lower cock being the water level of the boiler; *f* is the fire door. The lower figure on the left hand side of the cut, No. 2, is a section of the boiler when set, and shews the mode of conducting the funnel from the fire before passing up the chimney, the upper surface of the tubes are covered with a plate of iron, and filled in with sand, to prevent radiation of heat. Instead of brickwork below the boiler, the tubes may be supported by sheet iron and pillars, as represented in the right hand figure. Figures No. 3 and 4 represent the manner the tubes are fastened.

Although the advantages which have been mentioned and explained, gave this boiler a decided superiority, there was one objection which appeared to be fatal to its introduction into naval purposes, the use of salt water was impossible, on account of the rapidity with which the salt was deposited in the tubes, and the inconvenience and difficulty of removing it, and also its corrosive effects on the tubes; to remedy this however, an apparatus something similar to the boiler, has been invented by Mr. Gurney, and successfully applied in condensing the high pressure steam, instead of letting it off to waste, and returning the water so procured by means of a force pump into the boiler, so that by beginning with pure rain or distilled water, steam is continually generated, without any considerable expenditure of fresh water, as the steam from the engine is not only condensed, but also a portion of that procured from the salt water, which is necessarily employed in condensing it, and which can, without loss of power in a steam vessel, be led, from the water thrown up by the paddle wheels to a cistern for the purpose. The description of the condenser is as follows.

Fig. 27.



The elbow pipe *a*, No. 1 of Fig. 27, is connected by one flaunch with the eduction way of the engine, and by the other to the cone of the condenser, which for a 10 horse power engine, is a cylindrical vessel of 3 feet 6 inches long, and 7 inches internal diameter. In this cylinder are placed in circles forty copper tubes, 5-8ths in diameter, which are inserted into plates at each end, as shewn in 2 of the same figure, by steam tight joints. The nozzle *c* is connected to a cold water pump, throwing about two gallons of water per horse power per minute. This however is not necessary in a ship, as water can be procured as before stated from the paddles. This water will rise in the cylinder, encircling the tubes, until it is ejected at the nozzle *d*, from whence it may be permitted to return to the well or cistern. The steam passing from the engine into the tubes is condensed before it reaches the lower cone *e*, and falls into the close chamber underneath, and the water is taken from thence by the suction pipe *g*, connected to the injection pump of the boiler. When there is any deficiency of water in the lower chamber, the ball attached to the cock balls, and admits the requisite quantity from the condensing cylinder, through the tube connected at *i*; and *k* is a tube from which any air or uncondensed vapour may be drawn out by a small air bucket, or otherwise be permitted to escape. In the experiment Mr. Gurney made, and which I saw, the condenser was applied to a high pressure engine when the steam in the boiler was at a pressure of 60 lbs. on the inch, an unloaded valve was placed on a tube inserted into the elbow *a*, but so perfect was the condensation, that the steam had not even sufficient force to lift the valve. The water entered the nozzle *c*, at a temperature of 50 degrees, and was ejected at a temperature of 112, and the temperature of the fluid ejected was 150. This ingenious plan of Mr. Gurney, makes his boiler quite perfect for naval purposes, and the additional weight and space required, is very trifling. A boiler, condenser, and pair of engines of 20 horse power, constructed by Mr. Gurney, does not exceed 4 tons in weight: the cylinder used in this instance, was a vibrating one, but they may of course be constructed to work with guides, either horizontal or parallel.

Fig. 28 shews the form and construction of Mr. Gurney's engine, as applied to maritime purposes, on which account it is shown as placed

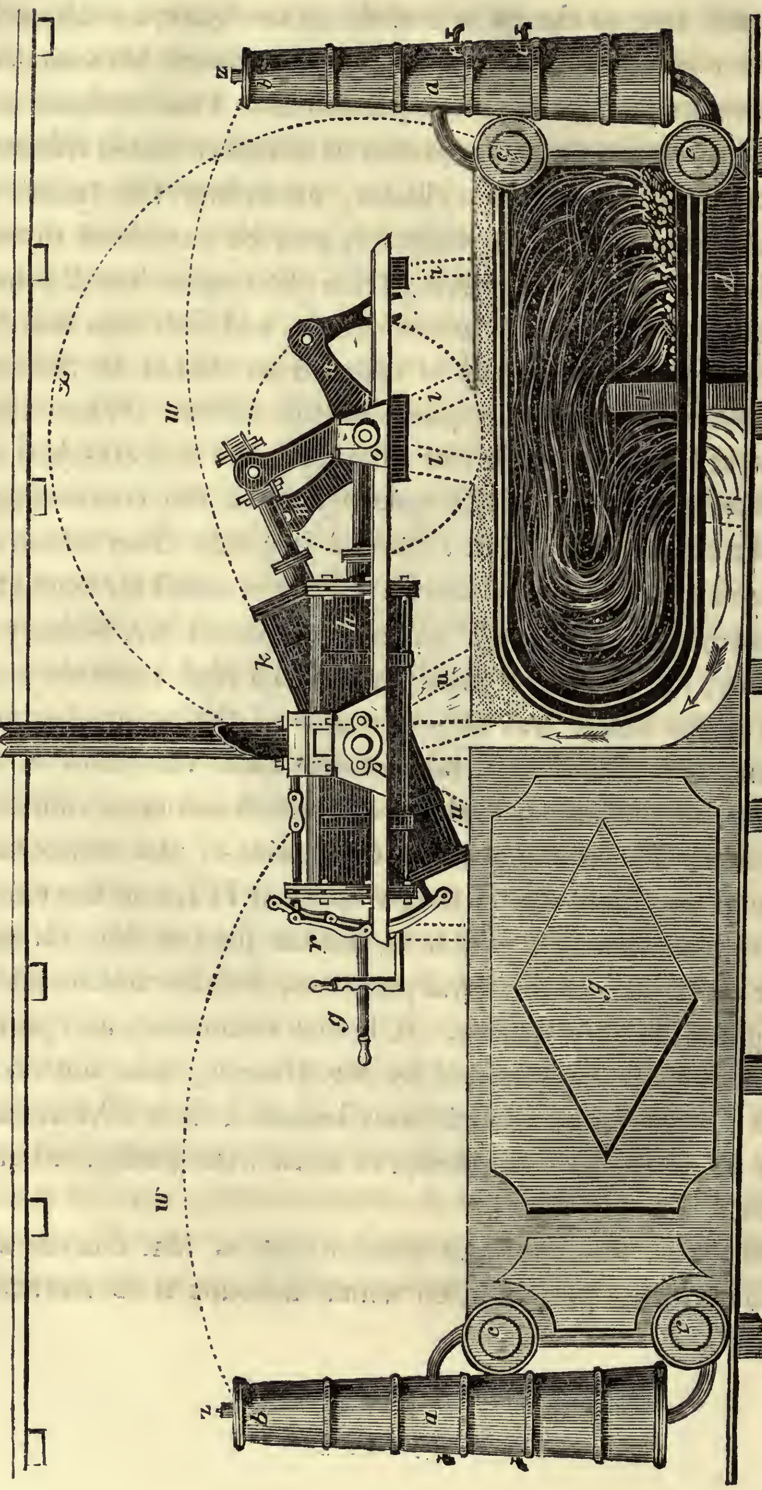


Fig. 28.

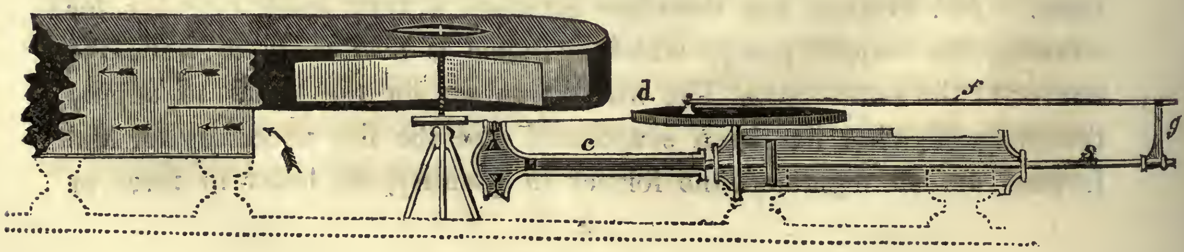
between the two decks of a vessel. Two boilers, such as have been before described, are made use of, and the stand back to back, so that the firing doors may be at the right and left hand ends of the machine. The left hand boiler and fire place *g* is shown with a side or case, as it really appears when in work, but the side is removed on the right hand side of the figure to show how the fire is applied, and the direction which it takes, as indicated by arrows, to get into the chimney pipe or flue *s*, which is common to the two boilers. *d* is the ash pit, and *r* the bridge for directing the passage of the flame. The ends of the water reservoirs into which all the small pipes that form the boiler open, are shown at *c c*, and *a a* are the separators furnished with safety valves at *b b*, and with guage cocks at *e e*. The engine itself is without any beam or parallel motion, and to compensate for the use of these the steam cylinders are hung on trunnions like guns, so that they can vibrate up and down; thus *h* and *k* in the figure show the two cylinders of a double engine, and *p* is the pivot or trunnion upon which the cylinder *h* vibrates. The steam enters the cylinders through side pipes communicating with these trunnions, which, by their motion, at the same time answer the purpose of the cocks or valves for admitting and shutting off the steam at the proper moments, such opening and shutting of the valves being further assisted by a series of levers *g r*, which act in the manner of hand gear. The steam is brought from the separators to the trunnions of the cylinders by pipes placed in the direction of the dotted lines *w w*, and the piston rod of each cylinder is attached to a crank *m n*, both rising from the main shaft *o*, and standing at right angles to each other. The paddle wheels of the vessel are hung upon the two ends of the main shaft *o*, as indicated by the large dotted circle *x*, and this shaft, together with the trunnions of the cylinders and the other working parts of the engine, are supported on frame work marked *i i i u u*. In this construction of engine all the effective force of the piston is applied directly to the main shaft, without any waste of power or room by applying a beam, and it therefore appears to me to be the best form of engine to be applied to maritime purposes.

The power of the steam engine is so influenced by the state of the fire, that in land engines no expense is spared in the building of effective stacks of chimneys for the purpose of ensuring great and powerful drafts, so much so that it is not unusual for a chimney to the furnace of an engine of 20 horse power to be built at the expence of £500. In some of the mines in Cornwall, where large engines are employed, the stacks are towering and ornamental, and look more like representations of Trajan's Pillar at Rome than ordinary flues for smoke; so much importance and respect do engineers attach to them. In steam ships the subject is equally important, though here unfortunately we are limited in many particulars of great consequence to the engine, from the circumstances of its situation above the deck. The height, size, weight, &c. are all defined, and cannot be extended without producing a more than reciprocal disadvantage to the sailing or the safety of the vessel. The chimney, or funnel, as it is technically called, was amongst the most prominent objections to the first use of steam at sea, such is the public opinion, not so much from any real disadvantage, but simply as a matter of taste. Many attempts have been made to substitute an artificial draft or blast for the present chimney, but hitherto without success; the construction of the furnace and also the nature of the fuel have been tortured with a fruitless view to the same end. The failure of blasts of all kinds has been occasioned partly by their requiring an expensive power to produce them from the engine, but principally from the manner in which these blasts have been applied. In most cases they produce, as in a smithy, an intensity of fire without quantity, which the boiler has either been unable to conduct to the water, or else has been transmitted so partially and locally as to effect the rapid oxhidation and destruction of the plates. At length a modification of the centrifugal blast has been discovered, and applied by Mr. Gurney in a manner which promises to remove the practical difficulties, and will probably set the question at rest. This consists simply in taking advantage of the peculiar action of fluids, when set in motion on those which are at rest. A rotatory or centrifugal blower is constructed in the common way, and the blast is caused to unite in the direction of the usual trunk, and at the periphery, with the air in a second trunk opening to the atmosphere at the one end, to the wind channel going to the furnace at the other. This current of air is diffused by the trunk which terminates below the whole furnace over a large body and surface of fire, at a very low and constant pressure, sufficient merely for the perfect ignition of every part of the fuel or carbonaceous matter in the furnace at the same instant, and so generally is the fire dispersed over the metallic surface of the tubes, that the reception of the heat for the generation of steam is every where equal, and the power of the fire can be increased to a much greater intensity of heat than the draft of any flue could do, and it can be modified and regulated at pleasure. It should be remarked here, however, that Mr. Gurney's boiler, which has already been described, offers a greater extent of surface to the fire than any other in proportion to the water it contains, absorbing the heat instantly and completely when it is so distributed by the current of air.

The regular supply of water in tube boilers, which contain little in quantity, is so important, that it would be folly to trust to the action of the working engine, or to manual labour, for the purpose of supplying them. Mr. Gurney has therefore attached a very small cylinder for working the supply pump, which cylinder is also made to work the blower at the same time. The water requisite for the boiler to supply the place of what has been evaporated and the fire necessary for the furnace are so regulated, the former in quantity, the latter in force or power by this means, that the action on each is uniform and co-existing; consequently without water in the boiler there can be no steam, and the engine which turns the boiler will stop, and no fire capable of injuring the boiler under such circumstances can be kept up. Again, without fire there can be no undue action of the feed pump, either to *drown* the engine, as it is called, or to waste the power of heat. If the blower is turned round with great violence, and an intense heat is thereby effected, there must be at the same time an uniform increase of water by the pump to be converted into steam. Again, instead of any power being actually lost by the addition of this small cylinder and apparatus, the reverse is found to be the fact, because the power taken from the engine to effect this purpose is less than that lost by the present system; so that besides the great advantage of entirely doing away with the enormous funnel or chimney, others of no less consequence will be obtained, namely, that in the first instance, by the labour of only one man, the steam can be got up in three minutes, after which it works the blower itself; secondly, the smoke being made to pass over a flame will be nearly consumed, and the remainder, together with the heated air, blown into the sea. A steam vessel cannot consequently be discovered by the smoke, which, in naval warfare, forms so serious an objection; and lastly, the expence of the funnel will be saved and that of the fuel much diminished.

The apparatus will be better understood by the following description and diagram.

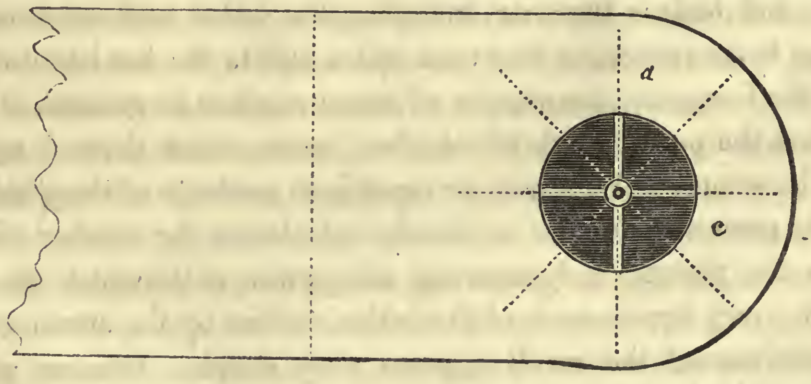
Fig. 29.



a is a small cylinder, *s* a piston rod to turn the fly-wheel *d* by means of the rod *f* and *g*, a similar rod at the other end of the cylinder forms the plunger of the feed pump *c*. The fly-wheel *d* communicates by a band to the drum *d*, which on the upper end of its spindle carries the vanes or sails of a fan which revolves within a close trunk, underneath which is another trunk, communicating with the atmosphere and afterwards forming one general trunk, which conducts the current of air in the direction of the arrows. The throttle valve regulates the engine in the usual manner as to power and velocity.

Fig. 30 is a plan of the blower inclosed in its case: *a* the drum, in the centre of which is the aperture for the air to enter, *c* the fans or vanes of the blower, *d* the air trunk, *e* the second trunk which conducts the current of air to the generator in the direction of the arrows.

Fig. 30.



The following are the present prices of engines manufactured by Messrs. Busk and Keene, to whom Mr. Gurney has made over the naval part of his manufactory.

" The price of a boat ten horse power engine, single or with only one " cylinder, is £400, as it goes out of the manufactory, including reverse " valve action, separate expansion valve, boiler, and condenser for " returning the steam as distilled water into the boiler after passing the " cylinder, but exclusive of chimney. Iron case, if required for the " boiler instead of setting it in brickwork, and the paddle wheels and " shafts, and also fixing in the boat these collateral matters would come " to about £100 more. To get the price of engines of any greater or " less power than that of ten horses, add or deduct as required £30 per " horse power; thus the price of a twenty horse power would be £700, " the above collateral expenses would vary in about the same proportion.

" When a pair of engines or two separate engines are used, the price " of each engine is to be ascertained as above.

" The price of a ten horse power boiler alone is £100, and of a cor- " responding condenser for the above purpose £15; larger powers are " nearly in the same proportion but rather lower; the weight of the " engines and boilers together, including the water, will not exceed five " cwt. per horse power, or two tons and a half to the ten horse engine.

From the foregoing description of steam engines in general, it will be evident that the power with which they move, must depend upon the force of the steam, and the area or superficial contents of the piston upon which it is permitted to act; so that by calculating the number of square inches in the piston, and knowing the power with which the steam presses on every square inch of the boiler, (either by the steam guage or other contrivance,) the result appears very simple; because we have merely to multiply the area of the piston in inches by the force of the steam in pounds, ounces, or other denominations of weight, and the result will be the force with which the piston should move, expressed in the same denomination. If therefore the piston of a single acting engine be 54 inches diameter, such piston will contain very nearly 2291 square inches of surface, and if the barometer of the condenser indicates that the air pump is maintaining a good vacuum within it, and the steam guage of the boiler stands at 2 inches, or shows that the steam is equal to two pounds on the inch, while the household or weather barometer stands at 30 inches; then the force acting on such a piston to depress it, will be 38,945 lbs. or rather more than 17½ tons; for if the vacuum was perfect, it would permit atmospheric pressure alone to operate at the rate of 15 lbs. on every inch when the barometer was at 30 inches, and as the steam is two pounds to the inch more powerful than the atmosphere, so of course there would be a pressure of 17 lbs. on every square inch of the piston which would produce the above result. This enormous force is no doubt called into action, but notwithstanding this is the case, yet from the little steam that remains uncondensed in the pipes, the unavoidable imperfections, even of the best workmanship, and the friction and inertia of a complete steam engine, it is found that the actual quantity of disposable power, or that which is left by the engine to drive other machinery, after producing its own motion, cannot fairly be averaged at more than about 7 lbs. on each inch of the piston. In large machines, the friction is less in proportion than in smaller ones, and consequently a greater allowance may be made, particularly when the weather barometer stands above 30 inches, which is seldom the case for long together. A small engine on the contrary, requires a greater allowance, and therefore in taking the average size of condensing engines, together with the average height of the barometer, state of the air pump, and strength of steam used with them, from 7 to 7½ lbs. is as much as can fairly be considered as the disposable operative force upon their pistons; and consequently out of the 38,845 lbs. of power operating on the piston above named, no more than 16,036 lbs. or thereabouts can be considered as acting force. Some engineers allow half the actual power to remain as disposable force; but at all events, half the actual power must be considered as lost, or absorbed in friction, resistance, &c. and hence it appears how very desirable it is to strip the engine of its beam, crank, fly-wheel, air and cold water pumps, and in fact, every thing that can produce friction, resistance or inertia, and upon this are the chief hopes of those who have laboured to produce good rotary engines grounded. The high pressure engine likewise derives some of its best properties from this circumstance, for independent of its greater simplicity, its friction is diminished by all its working parts being smaller; and even if this were not the case, it would bear a less proportion to the power of its steam. If a condensing engine, working at 14 lbs. to the inch loses 7 lbs. nearly half the power of the steam is wasted; but if that same engine was worked by steam of 40 lbs. the friction would still remain the same, and would amount to little more than a sixth part of the power of the steam.

In this way, by consulting the barometer and the steam guage, may the force acting on any piston be determined; or the reverse of the proposition, for if the amount of any load be known, there can be no difficulty in calculating the size of a piston that shall overcome it with any given power of steam. But before we can come to any comparative statement of the power of a steam engine, so as to obtain definite ideas of what it can perform, we must consult the velocity of its motion as well as its force. Steam engines on their first introduction were very frequently used as substitutes for horse mills which had preceded them, and hence if a mill had been worked by two or more horses it became necessary to construct the engine in such manner that it should be equal to the work of so many horses; for if rendered more powerful than necessary, a waste of fuel must ensue, while on the contrary, if not powerful enough, the work would not proceed in a satisfactory manner. It therefore became customary to designate engines by *horse power*, a custom, than which, nothing can be more vague and unsatisfactory, though continued in some few instances to the present day. The best mechanics are by no means agreed as to what the actual power of a horse is, or should be called, nor is it likely that such an agreement can take place, when it must be dependent on the age, size, health, and vigour of the animal, as well as on the food, climate, and position in which he works. Nothing more than a rough average can therefore be taken, and this is by no means to be put into competition with the certain results that are always obtained from perfect machinery. Messrs. Boulton and Watt, call the average power of a horse equivalent to raising 33,000 lbs. 1 foot high in a minute, and say that he can continue this work for 8 hours in a day. For an engine to be equal to the power of a horse, it must therefore not only raise this same load, but must move it with the same velocity, for power and velocity can never be separated in the investigation. By moving the load, we are to understand moving it by the piston, and consequently, if the piston rod of an engine rises or moves 1 foot in a minute with a weight of 33,000 lbs. upon it, the engine to which it belongs must, according to Watt and Boulton's estimate, be a one horse engine. No steam engine however moves at this slow rate, but from numberless experiments that have been made, it is found that from 200 to 220 feet in a minute, is the best speed for a piston to travel; hence, small engines work much more rapidly than large ones; for if the cylinder of a double engine is so small as only to admit of a 2 feet stroke, its piston must ascend and descend 50 times in a minute, to pass through 200 feet, while an engine having a 10 feet stroke, will make but 20 alternations in the same time, or move upwards and downwards 10 times. Now since the one-horse engine before mentioned, would pass through 200 feet instead of one foot in the minute, it need only carry one two-hundredth part of its former load, or 160 lbs. to give it the same power; for 160 lbs. moved 200 feet in a minute, is the same thing as 33,000 lbs. moved one foot in the same time. If therefore we can ascertain the weight that any engine lifts, and the distance to which it carries it in any given space of time, it becomes easy from such data to determine how many pounds avoirdupoise are raised one foot high in a minute, and dividing this by Watt and Boulton's denomination of power as before given, or any other that may be adopted, to ascertain its value in horses power.

With respect to the quantity of coals consumed by engines when computed according to horse power, one bushel is the allowance usually made for each horse power for a day's work; but the day when spoken of, as applying to horse's work, is but 8 hours of actual labour. This allowance has by many been considered as insufficient, and for small engines it is perhaps not quite ample. But there is no doubt, that if an engine is kept constantly worked, one bushel per horse power for each 8 hours work will be fully sufficient.

All that I have heretofore said applies to the steam engine only, but attempts have been made within the few last years to obtain motive power from other sources, and among these the experiments of Mr. Brown and Mr. Brunell, the well known engineer, deserve to be mentioned. Mr. Samuel Brown, of Old Brompton, obtained his first patent in 1824 for a machine which he called a *Gas Vacuum Engine*, and the machine which he then invented has been described and represented in many periodical works. It was, however, on its first introduction so complex and inconvenient, that Mr. Brown, in the course of the numerous experiments he tried upon it, was obliged to so far alter and modify it, that he obtained a second patent for its new form and improvements in 1827, and it is now so completely simplified that it promises to be a very useful machine in many cases.

Mr. Brown uses hydrogen gas, or inflammable air of any kind, instead of steam to work his engine. The principle upon which he proceeds has been known, and applied in a small way to the surgical operation of cupping, though he certainly is entitled to the invention of applying it to the production of a new motive power. It is well known that heat, and the heat of flame in particular, has the power of expanding the volume of any air into which it may be increased to a very great extent. Accordingly Mr. Brown uses a cylinder or box, which need not be bored or made with any particular care, except as to its being perfectly close and air-tight in every part, except the top, which is moveable, but when shut is likewise air-tight. A small pipe proceeding from a reservoir of inflammable gas, enters the bottom of this cylinder, and terminates within it in a rose head like that of a watering pot, and there is a cock below it to shut off the gas or permit it to flow. A jet of similar gas is kept constantly burning opposite to a small sliding valve in the side of the cylinder, and in such a direction that whenever the valve is opened the flame will enter the cylinder, and instantly ignite the streams of gas that flow upwards from the rose head, thus filling the whole cavity of the cylinder with flame, which burns so long as the cylinder top and the gas cock remain open. But by a simple contrivance the burst of flame is no sooner produced than the cylinder lid falls, and by so doing shuts both the gas cock and the lighting valve, consequently the flame is as instantly extinguished, and the inside of the cylinder left in a state nearly approaching to a vacuum, and it is the vacuum so produced that Mr. Brown employs for the production of power. The power is produced in two ways. First, it may be employed to produce a similar vacuum on one side of a piston working in a cylinder, while the pressure of the atmosphere operates on the other side of such piston, in which case its operation is very similar to that of the single and double acting steam engine, or no piston need be used, but instead of it a suction pipe containing a valve opening upwards like the feeding pipe of a pump, may descend into a well or reservoir of water to be raised, when the vacuum produced in the cylinder will be supplied by water, provided it is not beyond the reach of atmospheric pressure, and that water may be discharged through a large side valve in the cylinder between each production of flame, and may be conducted over an over-shot water wheel to produce rotatory motion. One cylinder only has been spoken of, but Mr. Brown uses two, three, or more, in which the flames are produced in such rapid succession that the vacuum produced may be said to be almost perpetual and uniform.

The vacuum produced in this way is certainly not so perfect as that produced by steam, but still it is capable of maintaining the quicksilver in the guage tube at about two-thirds of the height to which it would be raised by a perfect vacuum, so that a disposable power of from eight to ten pounds on the square inch may be obtained; and as this engine is of small weight and needs no expensive workmanship, as none of its cylinders are bored, and requires neither a large and heavy boiler or chimney, and no supply of water or coals, it promises advantages if brought to perfection which no othrr engine can afford, for when packed pistons are not used there is little or no loss from friction, the machine may be started at a moment's notice without waiting for water to boil, and it is attended with no expence except when it is actually at work. Mr. Brown has lately fitted up one of these engines to work a pair of paddle wheels, in a boat of twelve feet beam, upon the river Thames, and the experiment succeeded in many trials to his utmost wishes. The only point, therefore, that remains to be determined is whether power can be obtained from the combustion of inflammable gas at as cheap a rate as from coals, and if this should be established there is no doubt of the gas vacuum engine becoming highly valuable, particularly for naval purposes, on account of its making no smoke and having no chimney, objects which must always more or less interfere with the secret service of steam vessels, on account of the great distance at which they may be discovered by their smoke. This same object was one of those which induced Mr. Gurney to turn his attention to the blower of the fire before described, because by its use coke, charcoal, and other fuel emitting little or no visible smoke could be made use of.

The attempt of Mr. Brunel, before alluded to, has so far been less successful, owing probably to a want of sufficient acquaintance with the materials he had to make use of. Previously to 1823 carbonic acid gas or fixed air was, together with all the other airs and gases, thought to be permanently elastic, or incapable of assuming a solid and visible appearance, but about that time Mr. Faraday, of the Royal Institution of London, made the important discovery that this gas, as well as several others, might be reduced by mechanical pressure into a visible liquid form resembling water, but that by afterwards raising the temperature of the fluid so obtained it reverted back into its former state of gas with astonishing rapidity, and of course occupied a much larger volume than when in its liquid form, insomuch that when the liquid was at the freezing temperature of water, and was afterwards expanded into gas by a very low heat, it exerted a force equal to 30 atmospheres or 450 lbs. upon the square inch, and burst the vessels in which the experiments were tried.

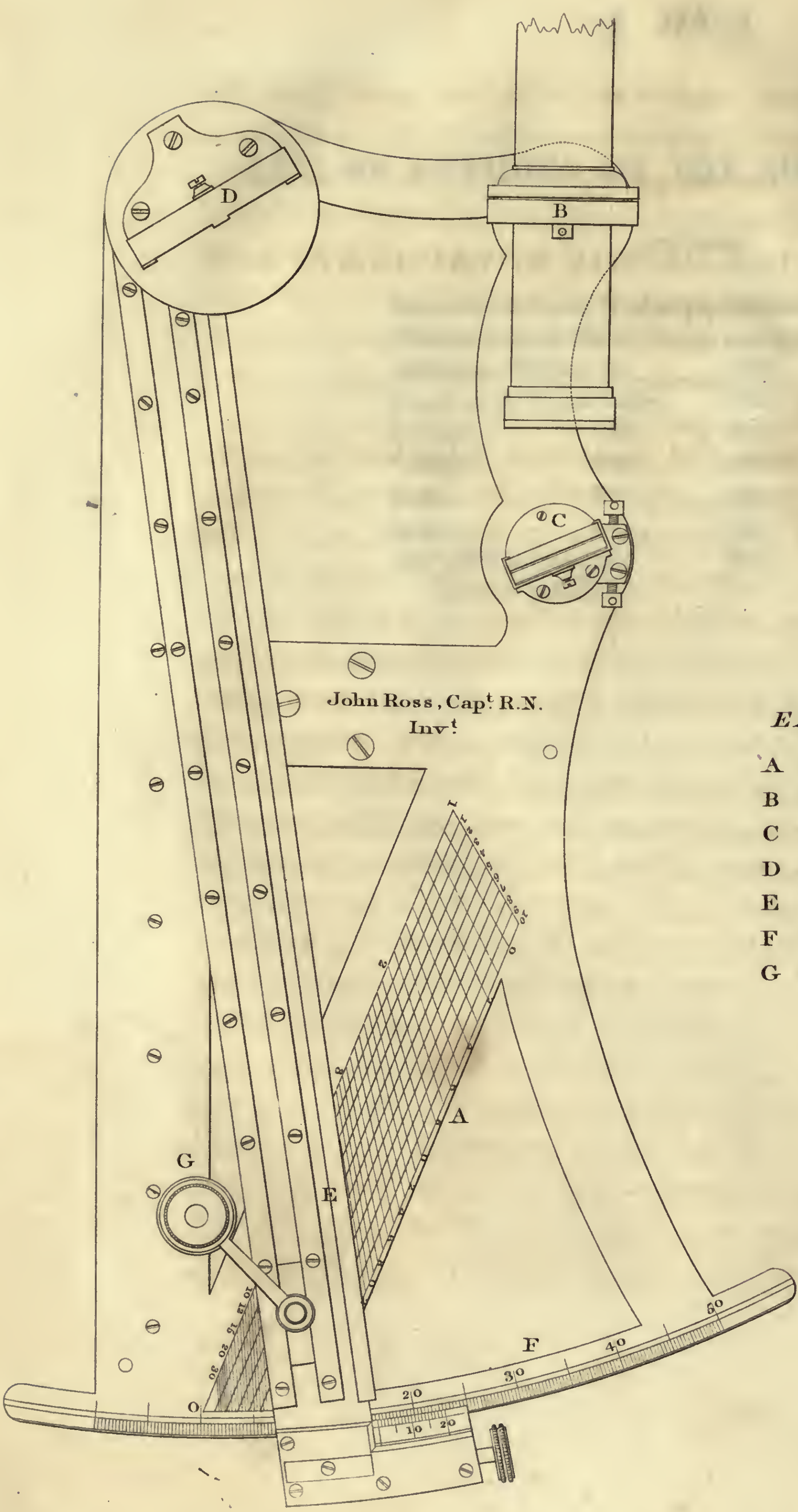
To construct an apparatus, by which a power so immense, and apparently so economical, might be rendered available like the steam engine, it will easily be conceived, has occupied the attention and study of many men of science, not only in this country but on the continent; but the only machine that has appeared before the public, is that of Mr. Brunel, whose constant avocations at the Thames Tunnel, have prevented his paying that attention to it, which would otherwise most probably have brought it to maturity. He has, however, obtained a patent for his contrivance, which may at some future period become important and useful. At present, it has not been practically applied to any useful purpose, and therefore I shall not enlarge upon it, or anticipate the prospects of its ingenious inventor. An account and representation of the machine copied from the specification of Mr. Brunel's patent, will be found in the Third Volume of the Register of Arts and Sciences, page 258, from which it appears, that the construction of Mr. Brunel's machine, is very nearly similar in form and construction to the steam condenser of Mr. Gurney, shown at Fig. 27. It consists of a very strong cylinder or other metal vessel, through the middle of which a number of small thin copper pipes pass, and open into a chamber above and below, without any connection or opening into the large cylinder. The large cylinder is to be filled with carbonic acid gas, reduced as before mentioned to a liquid state, and the small tubes that pass through it, are for the alternate transmission of cold and hot water, or steam to heat and cool the liquid. Two of these machines are to be used at once, by fixing pipes of connection from the part containing the liquid, and conducting one to the top, and the other to the bottom of a common close-topped steam engine cylinder, with a packed piston. The cocks or valves are to be so disposed, that while hot water or steam is passing through the small pipes in one vessel, cold water may be running through those in the other. Now, from the expansive nature of the carbonic acid gas liquor, if hot water, say at 120° is passed through the tubes of one vessel, while cold water at 50° or 60° is passing through the other; the liquid in the first receiver will expand, and operate with a force of about 90 atmospheres on one side of the piston, while that in the second vessel, will only exert about 40 or 50 atmospheres against the other side of the piston, and consequently, it will be moved with a force equal to the difference of the two pressures, or from 40 to 50 atmospheres, and the power will increase with a greater difference in the temperature of the two vessels. Having produced this first action, it may instantly be cut off and reversed, by reversing the position of the hot and cold water cocks, and letting cold water flow through the first vessel, while the hot water passes through the second. In this way, there appears to be every probability of a most powerful first mover of machinery, in a very small compass and at little or no expence; for carbonic acid gas is procurable at all times, from any acid applied to chalk, limestone, or marble, at a very small cost, and as the same gas works over and over again, without renewal, the only supply that could be required would be a trifling compensation for unavoidable waste. So far, however, some practical difficulties have occurred, which have prevented this ingenious contrivance from being brought into actual employment, and I shall therefore dismiss it without further observation until time and further experiments may have rendered it available.

I have extended my account of the steam engine, and the other modes of obtaining power to a much greater extent than I at first contemplated, from a desire of making my Brother Officers and the Service in general, acquainted with the nature and operation of these highly important machines, which have already been so advantageously introduced into the sea service for commercial purposes, and will I am persuaded, ere long be extensively used in the British Navy. The details of the construction of steam engines, and the mode of working and managing them, would be foreign to the present work, and greatly beyond its limits; but for the instruction of those who may wish for such information, I subjoin a list of all the works of any importance on these subjects down to the present time.

LIST OF AUTHORS ON THE SUBJECT OF STEAM.

Buchanan, on Steam Navigation,		published	Glasgow,	1816.
Partington, on the Steam Engine,		published	London,	1822.
Millington, Epitome, &c.		ditto	ditto	1823.
Stuart, on the Steam Engine,		ditto	ditto	1824.
Galloway,	ditto	ditto	ditto	1827.
Tredgold,	ditto	ditto	ditto	1827.
Farey,	ditto	ditto	ditto	1828.
Lardner,	ditto	ditto	ditto	1828.
Birkbeck & Adcock,	ditto	ditto	ditto, now in course of publication.	

ROYAL CLARENCE SEXTANT.



EXPLANATION.

A *The Clarence Scale.*
B *The Eye piece.*
C *The Horizon Glass* } *forming a Right angled Triangle.*
D *Index Glass.*
E *The Index.*
F *The Arc.*
G *The Microscope.*

Edmd. Turrell, del et sculp.

CHAPTER IX.

DESCRIPTION AND USE OF THE ROYAL CLARENCE SEXTANT.

THE most important part of this instrument is the Clarence Scale which extends from zero on the arc towards the horizon glass, and commences where the centre of the mirror on the index is in a line with 45° on the arch. It contains the multipliers from one to infinity, corresponding to the degrees, minutes, and seconds on the arc. These multipliers from one to twenty, are divided into thousand parts, those from twenty to forty into hundred parts, from forty to sixty into tenth parts, and from sixty onwards into units, &c. The eye piece horizon glass and the centre of the index mirror form a right angled triangle having two equal sides, and adjusting screws on the most approved plan, are applied to them. The instrument differs from the common sextant, by the index mirror being placed diagonally across the index, therefore zero is to the left instead of the right in reading off, and by moving the index the opposite way to that of a common sextant, the natural tangent of half the angle of any two objects is measured by reflection and can be read off on the arc, while the index bar, which is in form of a knife edge from the centre of its mirror to zero on the nonius intersects the Clarence scale, and gives the number to be used as the multiplier, which in all numbers can be read off at the point of intersection to thousand parts with great accuracy from one to twenty, by the microscope which is attached to it; the reading off then goes to hundred parts as far as forty, and so on. The eye piece is fitted with a good telescope, which has cross wires and a dark glass to correct the index error by the sun's diameter.

The use of the Royal Clarence Sextant is to determine the exact distance of the observer from an object in view near the horizon, which is done by a short and easy process.

1st. When the bearings and distance of any two objects from each other are known, which bearing line being at right angles, or nearly so, to the line from the observer's eye to one of the objects.

Hold the instrument horizontally, move forward the index until the objects are brought in one by reflection, then read off where the scale is intersected by the knife edge of the index, and you will have a number and its decimal parts, by which the distance between the two objects is to be multiplied to produce the exact distance in miles, yards, or feet, according as it is expressed, that the eye of the observer is from the nearest of these objects.

2d. When the bearings of any two objects from each other are known, but not the distance.

Suppose *b* in the diagram to be the position of the ship, and A and F the two known objects, bring one of these objects A to a bearing at right angles to the line A F uniting the two; take the angle A *b* F as before, run on a parallel *b* B, noting the distance run, until the object has the same bearing as the first had, then take that distance as the number to be multiplied by the multiplier found as before on the Clarence scale.

Or take the distance between one object and another on a part of the coast at right angles as A F C, which makes the angle A C B at the eye 45°, or set the instrument to 45° and mark the part of the coast where the reflected object covers it; then, set the instrument to 2 on the Clarence scale, run off in the same bearing C B, noting the distance until the objects are again in one, the distance run will be half that which the eye is from the object, or what is more useful, set the object at 2, note the marks on the land, then set it to 45° or one on the scale, and run in; the distance run will then be equal to the distance the eye is from the object.

3d. When the Chart of the coast in view is in your possession, (which is generally the case,) in sailing along the land the distance from it will be readily and accurately found, by setting the index to any particular number, and looking at the land through the telescope, with the instrument held horizontally, objects on it will be seen to coincide or cover each other, which being noted and measured by scale and compass, and the distance so found multiplied by the number given by the Clarence scale, the product will be the exact distance required.

4th. The coast, or any object, may be approached to any distance required, by setting the index to the particular number on the scale, which, by multiplying the distance between any two known objects forming a right angled triangle with the observer, will produce the distance required. The ship by sailing off or on brings these two objects in one by reflection, when she will be at the exact distance required, and the particular number is easily found by dividing the distance you wish to place your ship by the known distance of the two objects.

It is evident that the Clarence sextant will be found of great importance in surveying, in laying down, and in avoiding shoals, but most particularly in placing a bomb ship, which may be done as directed in article 4th with great accuracy, for it is seldom or ever that a fortress or town is bombarded without the distance between some two points in it being known, or that some distance can be measured between some two points; this being done, the anchor may be dropped within a yard, or even a foot of the range required. For example, at the battle of Algiers the distance between the light-house A in the diagram and the flag-staff F was positively known to be 400 yards, yet it is notorious that some of the bomb vessels could not hit upon the correct distance from the light-house, and that the shells were not thrown with good effect. The distance required was 1600 yards, which being divided by 400 gives the multiplier 4, to which number the knife edge of the index would be set on the Clarence scale, and when the bomb ship had approached until the light-house and flag-staff appeared in one by reflection, the anchor might be dropped within a yard of the distance required.

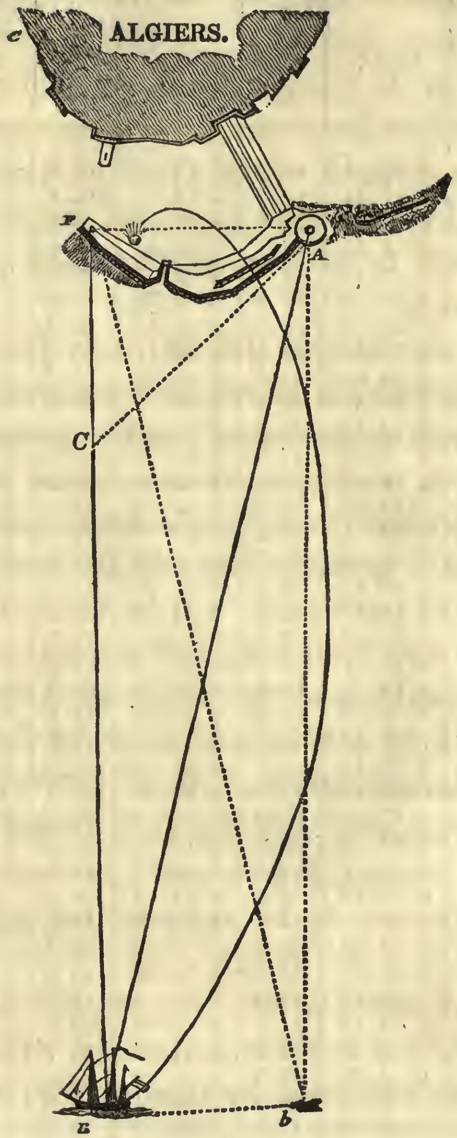
In like manner, line of battle ships and frigates, which are sent to silence a battery, will be able to take up their proper positions with accuracy and precision.

The distance of objects may also be easily found by measuring the height of any object which is known or unknown by the same process, and both methods may be successfully and importantly applied to steam vessels, particularly in warlike operations, where the exact distance that their shot would tell on an enemy is absolutely necessary.

A steam ship, made proof against shot at a certain distance, which is now ascertained to be practicable, will be enabled by this instrument to obtain her position, (say 1800 feet,) and to maintain it by simply setting the index to 18 the multiple of the length of the mast (say 100 feet) on the Clarence scale, as it will not only shew the exact spot she should be placed in, but by also denoting the alteration, it will point out with what velocity the vessel must be impelled or retarded to keep her station, when she may be compared to a one gun battery, which cannot be approached near enough to be reduced, but which must eventually disable the finest ship in the British navy.

The principle of the Clarence sextant has also been successfully applied to the arc of the common sextant, on which the Clarence scale has been engraved, and may be seen at Mr. Jones's, Optician, 62, Charing Cross.

Fig. 31.



The following Table for the computation of distances, has been constructed to be used with the sextants on which the scale has not been engraved.

Multiplier.	Angle.	Multiplier.	Angle.	Multiplier.	Angle.	Multiplier.	Angle.	Multiplier.	Angle.
1 0	45° 0′ 0″	5 9	9° 37′ 11″	10 8	5° 17′ 24″	15 7	3° 38′ 40″	23 0	2° 29′ 22″
1 1	42 16 25	6 0	9 27 44	10 9	5 14 31	15 8	3 37 17	23 5	2 26 12
1 2	39 48 20	6 1	9 18 36	11 0	5 11 40	15 9	3 35 56	24 0	2 23 9
1 3	37 34 7	6 2	9 9 44	11 1	5 8 52	16 0	3 34 45	24 5	2 20 14
1 4	35 32 16	6 3	9 1 10	11 2	5 6 8	16 1	3 33 15	25 0	2 17 26
1 5	33 41 24	6 4	8 52 50	11 3	5 3 26	16 2	3 31 56	25 5	2 14 45
1 6	32 0 19	6 5	8 44 46	11 4	5 0 47	16 3	3 30 38	26 0	2 12 9
1 7	30 27 56	6 6	8 36 58	11 5	4 58 11	16 4	3 29 21	26 5	2 9 40
1 8	29 3 17	6 7	8 29 20	11 6	4 55 38	16 5	3 28 6	27 0	2 7 16
1 9	27 45 31	6 8	8 21 57	11 7	4 53 7	16 6	3 26 51	27 5	2 4 57
2 0	26 33 54	6 9	8 14 47	11 8	4 50 38	16 7	3 25 37	28 0	2 2 44
2 1	25 27 48	7 0	8 7 48	11 9	4 48 13	16 8	3 24 23	28 5	2 0 34
2 2	24 26 38	7 1	8 1 2	12 0	4 45 49	16 9	3 23 11	29 0	1 58 30
2 3	23 29 55	7 2	7 54 26	12 1	4 43 28	17 0	3 21 59	29 5	1 56 29
2 4	22 37 11	7 3	7 48 1	12 2	4 41 9	17 1	3 20 48	30 0	1 54 33
2 5	21 48 5	7 4	7 41 46	12 3	4 38 53	17 2	3 19 39	31 0	1 50 51
2 6	21 2 15	7 5	7 35 41	12 4	4 36 38	17 3	3 18 30	32 0	1 47 24
2 7	20 19 23	7 6	7 29 45	12 5	4 34 26	17 4	3 17 21	33 0	1 44 9
2 8	19 39 14	7 7	7 23 59	12 6	4 32 16	17 5	3 16 14	34 0	1 41 5
2 9	19 1 32	7 8	7 18 21	12 7	4 30 8	17 6	3 15 7	35 0	1 38 12
3 0	18 26 6	7 9	7 12 51	12 8	4 28 2	17 7	3 14 1	36 0	1 35 28
3 1	17 52 43	8 0	7 7 30	12 9	4 25 58	17 8	3 12 56	37 0	1 32 53
3 2	17 21 15	8 1	7 2 17	13 0	4 23 55	17 9	3 11 51	38 0	1 30 27
3 3	16 51 30	8 2	6 57 11	13 1	4 21 55	18 0	3 10 47	39 0	1 28 8
3 4	16 23 22	8 3	6 52 12	13 2	4 19 56	18 1	3 9 44	40 0	1 25 56
3 5	15 56 43	8 4	6 47 20	13 3	4 18 0	18 2	3 8 42	41 0	1 23 50
3 6	15 31 27	8 5	6 42 35	13 4	4 16 4	18 3	3 7 40	42 0	1 21 50
3 7	15 7 26	8 6	6 37 57	13 5	4 14 11	18 4	3 6 39	43 0	1 19 56
3 8	14 44 37	8 7	6 33 25	13 6	4 12 19	18 5	3 5 39	44 0	1 18 7
3 9	14 22 53	8 8	6 28 59	13 7	4 10 29	18 6	3 4 39	45 0	1 16 23
4 0	14 2 10	8 9	6 24 39	13 8	4 8 40	18 7	3 3 40	46 0	1 14 43
4 1	13 42 25	9 0	6 20 25	13 9	4 6 54	18 8	8 2 41	47 0	1 13 8
4 2	13 23 33	9 1	6 16 16	14 0	4 5 8	18 9	3 1 43	48 0	1 11 37
4 3	13 5 31	9 2	6 12 12	14 1	4 3 24	19 0	3 0 46	49 0	1 10 9
4 4	12 48 15	9 3	6 8 14	14 2	4 1 42	19 1	2 59 49	50 0	1 8 45
4 5	12 31 44	9 4	6 4 21	14 3	4 0 0	19 2	2 58 53	55 0	1 2 30
4 6	12 15 53	9 5	6 0 32	14 4	3 58 21	19 3	2 57 58	60 0	0 57 18
4 7	12 0 41	9 6	5 56 49	14 5	3 56 43	19 4	2 57 2	70 0	0 49 7
4 8	11 46 6	9 7	5 53 10	14 6	3 55 6	19 5	2 56 8	80 0	0 42 58
4 9	11 32 5	9 8	5 49 35	14 7	3 53 30	19 6	2 55 15	90 0	0 38 12
5 0	11 18 36	9 9	5 46 4	14 8	3 51 56	19 7	2 54 21	100 0	0 34 23
5 1	11 5 37	10 0	5 42 38	14 9	3 50 23	19 8	2 53 29	150 0	0 22 55
5 2	10 53 8	10 1	5 39 16	15 0	3 48 51	19 9	2 52 36	200 0	0 17 11
5 3	10 41 6	10 2	5 35 58	15 1	3 47 20	20 0	2 51 44	300 0	0 11 27
5 4	10 29 29	10 3	5 32 43	15 2	3 45 51	20 5	2 47 34	400 0	0 8 35
5 5	10 18 18	10 4	5 29 32	15 3	3 44 22	21 0	2 43 35	500 0	0 6 52
5 6	10 7 29	10 5	5 26 25	15 4	3 42 55	21 5	2 39 47	1000 0	0 3 26
5 7	9 57 2	10 6	5 23 22	15 5	3 41 29	22 0	2 36 9		
5 8	9 46 57	10 7	5 20 21	15 6	3 40 4	22 5	2 32 41		

EXPLANATION OF THE TABLE.

The first column contains the numbers from one to twenty, divided into tenths; from 20 to 30 they are divided into halves; and from 30 to 1000 they are integers; these are to be applied as *multipliers* of the distance between the two objects in view, which subtends the angle at the eye taken by a common sextant, and the second column contains the angle corresponding to these multipliers.

RULE.

Take the angle between any two objects in view whose bearings from each other does not form an obtuse angled triangle with the eye of the observer, and with this angle enter the column of angles in the tables, opposite to which in the column of multipliers will be found the number by which the distance between the two objects is to be multiplied.

EXAMPLE.

The light-house A and flag-staff F on the mole of Algiers is distant from each other 400 yards, bearing N. by E. and S. by W.; a ship runs in with the light-house bearing W. by N. until the angle between the two points is found by the sextant to be 14° 2′ 10″, required the distance.

Distance	400	yards.
Multiplier corresponding to 14° 2′ 10″	4	
Distance required	1600	yards from the light-house.

Note.—The angle in this example being a right angle the distance will be exactly correct, but if it was within a right angle there would be an abbcration, for correcting which a table will hereafter be published, but it is of so little consequence that it need only be used where great accuracy is required.

If there remains any index error after the instrument has been adjusted, it must not be applied, as in other observations, by adding or subtracting the quantity + or —, but it must be corrected by the tangent screw previous to reading off the number on the Clarence scale.

The following Table shews the multipliers corrected, when the eye of the observer is equi-distant from the two observed objects, or forming with them an isosceles triangle.

Rt. No.	Is. No.	Rt. No.	Is. No.	Rt. No.	Is. No.	Rt. No.	Is. No.
1·0	1·125	2·0	2·1	3·0	3·1	4·0	4·01
1·1	1·2	2·1	2·2	3·1	3·2	4·1	4·11
1·2	1·3	2·2	2·3	3·2	3·25	4·2	4·21
1·3	1·4	2·3	2·4	3·3	3·35	4·3	4·305
1·4	1·5	2·4	2·55	3·4	3·45	4·4	4·405
1·5	1·6	2·5	2·6	3·5	3·53	4·5	4·504
1·6	1·7	2·6	2·7	3·6	3·63	4·6	4·612
1·7	1·8	2·7	2·8	3·7	3·72	4·7	4·701
1·8	1·9	2·8	2·9	3·8	3·81	4·8	4·80
1·9	2·0	2·9	3·0	3·9	3·91	4·9	4·90
2·0	2·1	3·0	3·1	4·0	4·10	5·0	5·00

The first column shewing the number of a multiplier for a right angled, and the second for an isosceles triangle.

APPENDIX.

APPENDIX.

CHRONOLOGICAL ACCOUNT

OF

Discoveries and Improvements on the Steam Engine,

INCLUDING PATENTS,

WITH REMARKS, ON THEIR APPLICATION TO NAVAL OR MARITIME PURPOSES.

220.—B. C.

It is not my intention or wish, to enter into the list of those who have devoted so many pages to controversy on the antiquity of the Steam Engine; but, referring the curious on that subject, to Millington, Stuart, and Farey, I shall proceed to remark, that, from the writings of the various authors, it is more than probable, that the celebrated Archimedes was the first who put into practice this powerful agent, and that it was by Steam that Syracuse was defended so nobly against the Romans, during the reign of Hiero the 2nd, 220 years before Christ;

2nd.—130. B. C.

which must have been antecedent to the Toy, described by several authors as having been invented by a Greek mechanic, during the reign of Ptolemy Philadephus, 130 years before Christ.

3rd.—1563.

Mathesius, invented the "Whirling Oelepile," a sphere made to revolve by steam, which it is stated was used for turning the spit.

4th.—1615.

De Caus, in his "raison de force," describes a spherical vessel, acting by the power of steam, but it does not appear that it was applied to any useful purpose.

5th.—1650.

About this time, air-engines were introduced, but they scarcely deserve notice.

6th.—1658.

Branca's Engine appeared, and is represented by a Negro's head, with a pipe from his mouth, conducting the vapour to the periphery of a mill-wheel, which having produced the rotative motion, acted upon other wheels. A description will be found in Stuart and Farey.

7th.—1663.

The Marquis of Worcester's invention is certainly the first on record, which deserves to be called a Steam Engine; and whether he himself tried it or not, the description he gives of it in his century of inventions, establishes the fact of his being the inventor; but the controversies on this point between Millington and Stuart, and others, are both ingenious and amusing, and to them we refer our readers.

8th.—1683.

Sir Samuel Moreland claimed the invention of a Steam Engine, for which he endeavoured to obtain a patent; but there is no description of the method of generating the steam, or the apparatus connected with it, although he gives a long account of the results of experiments on the expansion of steam.

9th.—1685.

Dr. Papin, a native of Blois in France, is considered by the French as the inventor of the Steam Engine; and there can be no doubt but he was the first who introduced the safety valve. This apparatus is mentioned at full length in the various works on the subject, on which there has also been an amusing controversy.

10th.—1698.

Captain Thomas Savary, whose Engine is described in the first Chapter of this Treatise, is certainly the first who put in practice the power of the Steam Engine to drain water; and his invention or application of the power, deserves to be recorded as original. He obtained a patent for raising water by the elasticity of steam, and by atmospheric pressure.

11th.—1699.

Amonton's Fire Engine was invented, and is described in several works.

12th.—1705.

Thomas Newcomen and others, having joined Captain Savary, they obtained a patent, for condensing steam under a piston, and producing a motion by its being attached to a lever.

13th.—1718.

Henry Beighton, of Newcastle upon Tyne, erected an Engine with considerable improvements, which are also described in the first Chapter.

14th.—1718.

Desagulier's Engine appeared about this time. This is an atmospheric engine, to which many important improvements were made, which are described in Stuart's and Farey's work, and alluded to in this.

15th.—1736.

Jonathan Hulls, of London, obtained a patent for propelling a boat by steam; and is undoubtedly the first person who applied that power to naval purposes, and is fully entitled to the honor of being the inventor.

16th.—1759.

James Brindley, of Lancashire, obtained a patent for his boiler.

17th.—1766.

Jahn Blakey, of London, made an improvement on Savary's Engine, and obtained a patent for it.

18th.—1769.

James Watt, of Glasgow, obtained his first patent, invented the condenser, enclosing the cylinder, use of oil and tallow, moving a piston by steam against a vacuum, &c.

19th.—1769.

John Stewart, of London, obtained a patent for a Rotative Motion.

20th.—1772.

John Crysel, of London, improved the furnace, and obtained a patent for it.

21st.—1776.

Smeaton made many improvements and calculations on the properties of steam, which will be found at length in Farey's Historical Account.

22nd.—1778.

Matthew Washborough, of Bristol, obtained a patent for a Rotative Motion.

23rd.—1781.

John Steed, of Lancashire, obtained a patent for the Crank Movement.

24th.—1781.

Jonathan Hornblower, Penryn, obtained a patent for two cylinders, a description of which is found in Chapter I.

25th.—1782.

James Watt, Birmingham, second patent for his Expansive Engine, six modes for regulating motion, double action engine, double cylinders, steam wheel, &c. a description of which is found in Chapter I.

26th.—1784.

James Watt, of Birmingham, third patent; parallel motion, locomotive engine, hand gear and valves.

27th.—1785.

James Watt, of Birmingham, fourth patent, a furnace for the consumption of smoke, and lessening the consumption of fuel.

28th.—1785.

Thomas Burgess, of London, patent for a Rotative Motion.

29th.—1790.

Bramah and Dickenson, of London, patent for a Rotative Engine.

30th.—1791.

James Sadler, of Oxford, lessening the consumption of steam and fuel, and gaining time and force.

31st.—1793.

Bramah, for improvements and additions to the Fire Engine, April 18th.

32nd.—1793.

Francis Thompson, London, for two separate cylinders.

33rd.—1793.

John Cooke, Description of his Steam Engine.

34th.—1793.

Mr. Francois, published his description of the improved Steam Engine.

35th.—1794.

Robert Street, London, patent for "Inflammable Vapour Force," by turpentine falling on hot iron to raise the piston.

36th.—1796.

V. C. Hanley obtained a patent for the saving of fuel.

37th.—1796.

John Pepper, Newcastle, obtained a patent for his method of saving fuel.

38th.—1796.

Francis Lloyd, of Woolstanton, for an improvement in the furnace.

39th.—1796.

John Strong, of Bingham, obtained a patent for an improvement of the valves.

40th.—1796.

William Rutley, of Manchester, obtained a patent for an improved mode of working the Steam Engine.

41st.—1797.

Edmund Cartwright, of Middlesex, obtained a patent for "Improvements in the construction, working, and application of the Steam Engine," 11th November.—Rep. Arts.

42nd.—1798.

Thomas Rountree obtained a patent for a furnace and blower.

43rd.—1798.

Jonathan Hornblower, 2nd patent for his new invented Rotative Engine.

44th.—1798.

William Rayley, of York, a patent for his philosophical furnace and boiler, &c.

45th.—1798.

George Blundell, of London, patent for an apparatus for saving fuel.

46th.—1798.

John Jackson, of Dockhead, patent for his mode of constructing Steam Engines.

47th.—1798.

Francisco Rapozo, of Lisbon, patent for his cylinder and valves.

48th.—1798.

G. Quieroz, of London, patent for a new cylinder and improved boiler.

49th.—1798.

Robert Delap, of Bouville, patent for his economical boiler.

50th.—1798.

John Wilkinson, of Castlehead, patent for his method of constructing a boiler and saving fuel.

51st.—1798.

Marquis of Chabannes, patent for the improvement of fuel.

52nd.—1799.

Mathew Murray, of Leeds, patent for the improvement of the Steam Engine, lessening fuel, lessening the expence of erecting Steam Engines, and producing more ready motion.

53rd.—1799.

E. G. Erkhasdt, of London, patent for saving fuel.

54th.—1799.

William Murdoch, Redruth, patent for valves, rotative engine, &c.

55th.—1799.

James Bishop, of America, patent for his rotative engine.

56th.—1799.

Samuel Rehe, of London, patent for an engine to transmit force.

57th.—1799.

Rev. Thomas Cooke, for applying fire to caldronic implements, the "carbo frugalist," &c.

1800.

58th.—Thomas Devey, London, patent for an improvement in fuel.

59th.—Pheneas Crowder, Newcastle, patent for the crank motion.

60th.—John and James Robertson, Glasgow, patent for a furnace for consuming the smoke, applied to a Steam Engine.

1801.

61st.—Edward Cartwright, 2nd patent, locomotive engine, and regulating the velocity of the Steam Engine.

62nd.—Richard Wilcox, patent for Steam Engine and furnace.

63rd.—William Hase, of Saxethorpe, patent for a new cylinder and improved boiler.

64th.—James Anderson, of Mounic, patent for saving fuel.

65th.—Mathew Murray, of Leeds, 2nd patent, parallel motion, air pump, safety valves, and packing.

66th.—Timothy Bramah, Pimlico, patent for safety, and other valves.

67th.—Earl Stanhope, patent for saving fuel.

68th.—Robert Young, of Bath, patent for saving fuel.

69th.—James Glazebrooke, patent for working machines by means of the properties of air.

70th.—William Lymington, of Kennaird, engine for a steam boat, and rotatory motion without a beam or lever.

1802.

71st.—James Sharples, of Bath, patent for mechanical powers applied to the Steam Engine.

72nd.—Thomas Parkinson, London, patent for the conveyance of various fluids.

73rd.—Richard Trevithick and Alexander Vivian, of Cornwall, patent for the high pressure engine; this is described in Chapter 1st, and will, with the tube boiler, supersede all other engines.

74th.—Bryan Evans, patent for saving fuel.

75th.—Mathew Murray, of Leeds, patent for the construction of a pump, and sundry other parts belonging to a Steam Engine, saving fuel, and increasing power.

76th.—Thomas Martin, of Brentwood, patent for applying fire to certain machinery of the Steam Engine.

77th.—Thomas Saint, of Bristol, patent for furnace, boiler, &c.

78th.—Joseph Quives, of Brinscombe, patent for a furnace to raise steam.

79th.—Mathew Billingsly, patent for the true boring of cylinders.

80th.—Richard Wilcox, Bristol, patent for air pump, boiler, and furnace.

81st.—Naucarrow, description of improvements on the Steam Engine.

1803.

82nd.—John Leach, of Merton Abbey, patent for improvements in construction of the boiler.

83rd.—Arthur Woolfe, London, patent for a tube boiler; this is described in 1st Chapter; it is what led to the construction of Mr. Gurney's improvement, which is now of such importance.

84th.—Edward Stephen, of Dublin, patent for saving fuel.

85th.—John Edwards, of London, patent for saving fuel.

86th.—Bryan Donkin, Dartford, patent for a rotatory engine.

87th.—William Fremantle, patent for his cylinder, pump, parallel motion and valves, described in 1st Chapter.

1804.

88th.—Richard Wilcox, 2nd patent for his furnace and improved boiler.

89th.—James Barret, of Saffron Walding, patent for saving fuel.

90th.—Arthur Woolfe, London, 2nd patent for double cylinders and high pressure steam boiler, described in Chapter 1st.

1805.

91st.—James Rider, of Belfast, patent for his cylinders and regulators.

92nd.—Charles Coe, London, patent for his method of applying heat.

93rd.—Jonathan Hornblower, of Penryn, patent for his steam wheel.

94th.—John Stevens, of London, patent for his improved boiler.

95th.—William Earle, of Liverpool, patent for his method of working and constructing the Steam Engine and boiler.

96th.—Alexander Brodie, of London, patent for his steam boiler and furnace.

97th.—James Boaz, of Glasgow, patent for his improvement on Savary's engine.

98th.—James M'Naughten, of London, patent for saving fuel.

99th.—Arthur Woolfe, of London, 3rd patent for his improved cylinder and piston.

100dth.—Richard Dodd, of London, patent for his method of saving fuel.

101st.—John Trotter, Esq. of London, patent for his steam wheel.

102nd.—William Dellever, of Blackwall, patent for his furnace and boiler.

103rd.—Andrew Flint, of London, patent for his steam wheel.

104th.—Samuel Miller, London, patent for certain improvements in the Steam Engine.

1806.

105th.—Thomas Bourne, William Chambers, and C. Gould, of Warwick, patent for roasting meat by the application of steam.

106th.—William Lester, of London, patent for a rotative motion or engine.

107th.—Ralph Dodd, of London, patent for his simplification of the engine and machinery.

108th.—Richard Wilcox, of London, 2nd patent for his rotative Steam Engine.

109th.—Josias Robins, of Liverpool, patent for his improved furnace.

110th.—Samuel Miller, of London, patent for saving fuel.

111th.—William Nicholson, of London, patent for his method of applying steam to various purposes.

1807.

112th.—Henry Maudsley, of London, patent for his portable engine, which is described in the 1st Chapter.

113th.—Allen Pollock, of Glasgow, patent for saving fuel.

114th.—Ralph Dodd, of London, 2nd patent for economy in heat.

115th.—James Bradly, of London, patent for furnace bars.

1808.

116th.—Thomas Mead, of Hull, patent for his steam wheel.

117th.—John Linklater, of Portsmouth, patent for his steam vessel.

118th.—Thomas Price, of Bilston, patent for his application of steam.

119th.—Thomas Smith, of Bilston, patent for various improvements on the Steam Engine.

120th.—Thomas Preston, of London, patent for the construction of a furnace.

121st.—Cawden and Partridge, of London, patent for saving fuel.

1809.

122nd.—Mark Noble, of Battersea, patent for his Steam Engine on a new construction.

123rd.—James Grellier, of Aldborough Hatch, patent for saving fuel.

124th.—John Murray and Adam Anderson, of Edinburgh, patent for their application of heat to the steam boiler.

125th.—William C. English, of Twickenham, patent for saving fuel.

126th.—John Fiscumeyer, London, patent for constructing and working Steam Engines.

127th.—Edward Lane, of Stoke on Trent, patent for an improved rotative engine.

128th.—John F. Archbold, of London, patent for a new application of heat.

129th.—William Johnson, of Blackheath, patent for his method of heating fluids.

130th.—Richard Scantleberry, of Redruth, patent for certain improvements in the Steam Engine.

131st.—Samuel Clegg, of Manchester, patent for his steel wheel.

132nd.—Nugent Booker, of Lime Hill, Dublin, patent for saving fuel.

1810.

133rd.—David Cock, of London, patent for heating fluids.

134th.—Arthur Woolfe, of London, 3rd patent for constructing Steam Engines, working and saving fuel.

135th.—William Clark, of Edinburgh, patent for the regulation of heat.

136th.—William Docksey, of Bristol, patent for his method of applying heat.

137th.—William Chapman, of Newcastle, patent for a new steam wheel.

138th.—John Justice, of Dundee, patent for a new application of heat.

139th.—Richard Witty, of Hull, patent for making Steam Engines, for arranging and continuing certain properties.

140th.—John Craigie, of Quebeck, patent for saving fuel.

141st—Stedman Adon, of Connecticut, patent for certain improvements.

1811.

142nd.—Richard Witty, of Hull, 2nd. patent for additions to his first invention.

143rd.—Joseph Miers, of London, patent for saving fuel.

144th.—Charles Broderip, of London, patent for certain improvements in constructing engines.

145th.—Michael Loyan, Rotherhithe, patent for fuel and generation of fire.

146th.—William Goad, of London, patent for improvement in valves.

147th.—John Trotter, Esq. of London, patent for improvements in the application of steam.

148th.—John Gilpin, of Sheffield, patent for a new application of steam.

149th.—Henry James, of Birmingham, patent for a new steam boat.

150th.—Thomas Deakin, of London, patent for saving fuel.

1812.

151st.—Henry Higginson, of London, patent for a steam boat.

152nd.—John Sutherland, Liverpool, patent for improved boiler and evaporating vessels.

153rd.—Henry Osborn, of Bordesley, patent for the manufacture of cylinders, &c.

154th.—R. W. Fox, and Joel Lean, of Falmouth, patent for improvements in the Steam Engine, and additional apparatus.

155th.—Jeremiah Steel, of Liverpool, patent for his method of applying heat.

156th.—William Onion, of Poulton, patent for an improved steam wheel.

1813.

157th.—John Slater, of Birmingham, patent for his improved boiler.

158th.—Robert Dunkin, Penzance, patent for saving fuel.

159th.—William Brunton, of Butterly, patent for erecting and constructing engines.

160th.—John Barton, of London, patent for several and various improvements.

161st.—Joseph White, of Leeds, patent for improvements in engines.

162nd.—John Sutherland, of Liverpool, patent for a new furnace.

163rd.—Charles Broderip, of London, patent for a new boiler.

1814.

164th.—Thomas Tudal, of York, patent for the construction of steam carriages.

165th.—William A. Noble, of London, patent for an improved Steam Engine.

166th.—R. W. King, of London, patent for boiling water and producing steam.

167th.—John Rastrick, of Bridgenorth, patent for improvements in the Steam Engine.

168th.—R. Dodd, and J. Stephenson, of Killingworth, patent for steam carriages.

169th.—William Lash, of Northumberland, patent for a new furnace.

170th.—H. Holdsworth, of Glasgow, for discharging the condensed steam.

171st.—Richard Trevithick, of Cambron, patent for a piston and for a Rotative Engine, which is described in the first Chapter. See Millington, Farey, &c.

172nd.—Mathew Billingsly, of Bradford, patent for certain improvements in the Steam Engine.

173rd.—William Moult, of London, patent for a furnace to a steam boiler.

174th.—Marquis de Chabannes, patent for saving fuel, &c.

175th.—W. and M. Bevan, of Glamorgan, patent for an improved furnace.

176th—John Cutler, patent for supplying fuel.

1816.

177th.—George F. Muntz, of Birmingham, patent for consuming smoke, and saving the products of it in a furnace.

178th.—S. T. Dawes, of Broomwich, patent for a parallel motion.

179th.—Bryan Donkin, of Surrey, patent for boiling water.

180th.—Philip Taylor, of Bromley, patent for applying heat to steam furnace.

181st.—William Heuson Coleford, patent for his improved engine.

182nd.—Alexander Rogers, of Halifax, patent for saving fuel.

183rd.—Robert Stirling, of Edinburgh, patent for saving fuel.

184th.—George Rodley, of Exeter, patent for improvements in the Steam Engine.

185th.—John Neville, of London, patent for a new mode of generating and applying steam.

186th.—John Gregson, of London, patent for supplying and reducing fuel.

187th.—William Lash, of Newcastle, patent for an improved furnace.

1817.

188th.—Moses Poole, of London, patent for certain improvements on the Steam Engine.

189th.—G. Mainwaring, of Lambeth, patent for certain improvements on the Steam Engine.

190th.—John Oldham, of Dublin, patent for improvements in steam boats.

191st.—George Stratton, of London, patent for saving fuel.

1818.

192nd.—Lord Cochrane and A. Galloway, patent for consuming smoke by a machine.

193rd.—Alexander Halliburton, of Wigan, patent for a steam furnace.

194th.—William Moult, of London, patent for improvements on the Steam Engine.

195th.—John Scott, of Penge, patent for the construction of steam boats.

196th.—Philip Taylor, of Bromley, 2nd patent for the application of heat.

197th.—John Munro, and others, of London and America, patent for improvements on the Steam Engine.

198th.—Joshua Routledge, of Bolton, patent for a rotative engine.

199th.—William Church, of London, patent for improvements on the Steam Engine.

200th.—James Ikin, of Christ-church, patent for furnace bars.

201st.—William Johnston, London, patent for consuming and destroying smoke.

202nd.—Marquis de Chabannes, 3rd patent for a tube boiler.

203rd.—Jones and Plimley, of Birmingham, patent for certain improvements in the Steam Engine, and boiler.

204th.—John Malone, of London, patent for improvements on the Steam Engine.

1819.

205th.—Henry Creighton, of Glasgow, patent for regulating the admission of steam.

206th.—Sir William Congreve, of London, patent for a new steam wheel.

207th.—James Frazer, of London, patent for his junction runnels in a boiler; remark, this is a very ingenious and effectual method, but expensive.

208th.—Richard Wright, of London, patent for the construction and subsequent employment of steam.

209th.—John Seaward, of London, patent for the raising of steam.

210th.—John Pontifex, of London, patent for an improvement on Savary's Engine.

211th.—William Brunton, of Birmingham, 2nd patent for an improved furnace.

1820.

212th.—Job Rider, of Belfast, patent for a rotatory engine by steam.

213th.—Joseph Parker, of Warwick, patent for consuming smoke.

214th.—John Oldham, of Dublin, 2nd patent for steam boats, and addition to former.

215th.—William Carter, of Middlesex, patent for certain improvements.

216th.—John Barton, of London, 3rd patent for engines and boilers for steam vessels.

217th.—John Hague, of London, patent for improvements in making and constructing Steam Engines.

218th.—John Wakefield, of Manchester, patent for a furnace, and an improved method of feeding fuel.

219th.—John Moone, of Dublin, patent for his rotatory engine, described in Stuart.

220th.—William Pritchard, of Leeds, patent for an improved furnace.

1821.

221st—William Addersley, of Middlesex, patent for certain improvements on the Steam Engine and boiler.

222nd.—Thomas Mastermans, of London, patent for his steam wheel, described by Stuart and others.

223rd.—Robert Delap, of Belfast, patent for his steam wheel.

224th.—Robert Stein, of London, patent for improvements on the Steam Engine.

225th.—John Bates, of Bradford, patent for feeding the furnace.

226th.—Jonathan Dickson, of London, patent for the transmission of heat.

227th.—Peter Devey, of London, 2nd patent for preparing the fuel.

228th.—John Pennick, of Penzance, patent for a new furnace.

229th.—Henry Brown, of Derby, patent for a furnace and consuming smoke.

230th.—Aron Manby, of Horsley, patent for the manufacture of engines.

231st.—Philips, London, patent for an improved furnace.

232nd.—Thomas Bennet, of Bewdley, patent for certain improvements.

233rd.—Francis Eyells, of London, patent for various improvements.

234th.—Sir William Congreve, of London, 3rd patent, addition to the former.

235th.—Charles Broderip, of London, 2nd patent for the construction of Steam Engines.

236th.—Julius Griffith, of London, patent for a steam carriage.

237th.—Niel Arnot, of London, patent for a furnace, and a boiler, on a new construction.

238th.—Richard Ormrod, of Manchester, patent for a boiler.

1822.

239th.—John Gladstone, of Castle Douglas, patent for the construction of steam vessels.

240th.—Alexander Clark, of Leuchars, patent for a steam condenser and boiler.

241st.—Jacob Perkins, of London, patent for a tube boiler, for heating water under very high pressure, described in 1st Chapter.

242nd.—Henry Brown, of Derby, patent for an improvement in boilers, whereby a saving of fuel is effected, and the smoke consumed. See Newton's Magazine.

243rd.—William Brunton, of Birmingham, improvements in fire grates and furnaces.

244th.—John Bambridge, of London, and others in America, patent for improvements in the rotatory engine.

245th.—Thomas Leach, London, patent for a steam wheel.

246th —G. H. Palmer, of London, patent for a new furnace, and for destroying smoke.

247th.—George Stratton, London, patent for consuming smoke.

248th.—George Stevenson, Long Burton, patent for consuming smoke.

249th.—Mr. J. Brunel, of Middlesex, patent for certain improvements on the Steam Engine, 26th June.

250th.—John Stanley, of Manchester, patent for a new method of supplying fuel to a furnace, 27th July.

251st.—Joseph Smith, of Sheffield, patent for an improvement in the Steam Engine boiler, 4th July.

252nd.—Thomas and John Burns, of London, patent for a Steam Engine boiler, and for propelling vessels.

253rd.—Nathaniel Partridge, of Bowbridge, patent for Steam Engine furnace.

254th.—David Gordon, of London, patent for certain improvements and additions to steam packets, applicable to naval and marine purposes. This consists in a mode of boxing the paddle wheels, or of enclosing them in a case. Remark, by this plan the vessel can be easily made proof against shot.

1823.

255th.—Bury and Bolton, patent for a rotatory Steam Engine, used entirely for hand purposes.

256th.—Union Canal steam vessel, contained 26 persons only, drawing 15 inches water.

257th.—William Johnson, Great Totham, patent for a boiler and furnace.

258th.—Thomas Neville, Surrey, patent for a boiler and furnace.

259th.—William Jessop, of Butherly, patent for a metallic piston.

260th.—Sir Anthony Perrier, Edinburgh, patent for a furnace and boiler.

261st.—Mr. J. Brunel, London, patent for certain improvements.

262nd.—Jacob Perkins, London, 4th patent for boiling water into steam.

263rd.—Thomas Peel, Manchester, patent for a rotatory engine, used on land.

264th.—Jacob Perkins, London, 5th patent for improvements on the boiler.

265th.—James Smith, Droitwich, patent for an improved boiler.

266th.—Fisher and Horton, West Brosnich, 2nd patent for improvements on the steam boiler.

267th.—William Jeakes, of London, patent for a water regulator to the boiler.

268th.—William Wigston, of Derby, patent for certain improvements.

269th.—Joseph Bower, of Leeds, patent for improvements which renders the air pump unnecessary.

270th.—Robert Higgin, of Norwich, patent for destroying the smoke.

271st.—James Surrey, of Battersea, patent for improved furnace, a new method for applying heat to produce steam, whereby the expence of fuel will be lessened.

272nd.—Captain Scobell, R. N. submitted a plan to the Admiralty, for applying impelling wheels to men of war, to be worked by winches, the capstain, or steam; also calculated for small vessels and boats.

273rd.—Jacob Perkins, 4th patent for improvements in the mode of heating, boiling, and evaporating steam.

274th.—Samuel Brown, of Windmill-street, Lambeth, patent for his new invented engine for effecting a vacuum, and thus producing powers by which machinery may be put in motion.

275th.—William Furnival and Alexander Smith, of Glasgow, patent for an improved boiler for Steam Engines and other purposes.

276th.—H. H. Price, of Glamorgan, patent for his invention of an apparatus for giving an increased effect to paddles, used in steam vessels, &c.

277th.—Thomas Timothy Benningfield, London, patent for certain improvements in Steam Engines, applying to rotatory engines.

278th.—Luckcock, of Birmingham, Essay on the Phenomenon of Heat, as applicable to Steam Engines, &c.

279th.—Samuel Hall, of Busford, Nottingham, patent for his invention of a new Steam Engine.

280th.—Mr. Perkins's Account of what led him to invent the steam gun is as follows:—He observed, during his experiments with his generator of high pressure steam, that all metallic substances were projected from the tube of the stop-cock with great velocity. It struck him that with a properly constructed gun barrel, bullets might be thrown with precision, power, and accuracy, and at the first experiment his hopes were realized, it threw 240 balls per minute, with a velocity greater than gunpowder; 40 atmospheres of pressure is known to be equal to gunpowder; an ounce ball was discharged from a musket with a common field charge, against an iron target, and another from a 6-feet barrel by steam, at 40 atmospheres of pressure, both at the same distance, when the former was much more flattened than the latter, proving the superior force of steam to gunpowder, the reason of which is evidently because the steam power acts with constant undiminished pressure on the ball until it leaves the gun.

281st.—George Vaughan, of Sheffield, patent for improvements on Steam Engines, by which means power will be gained and expense saved.

282nd.—John T. Paul, of Charing Cross, Westminster, patent for improvements in generating steam, and its application to useful purposes.

283rd—Jacob Perkins, of London, 5th patent for an improved method of throwing shells and other projectiles by steam.

284th.—W. H. James of Birmingham, patent for carriages to be propelled by steam on turnpike roads.

285th.—Thomas Peel, of Manchester, 2nd patent for a rotatory Steam Engine to produce motion.

286th.—A. Miles Sabin, of America, patent for improvements in the application of steam.

287th.—James Giraud, of America, patent tor improvements in propelling boats, and horizontal pedal water wheel.

288th.—B. S. Doxey, U. S. Navy, Baltimore, patent for paddle wheels to propel all kinds of vessels.

289th.—P. Davis, of New York, patent for a vibrating engine. This was invented by John Trotter, Esq. many years before.

290th.—M. Ward, Columbia, patent for improvement in the Steam Engine.

291st.—Thomas Skidmore, of New York, patent for improvements in boilers for Steam Engines.

292nd.—Thomas Skidmore, of New York, 2nd patent for improvement in condensers to Steam Engines.

293rd.—Stephen Baker, of New York, patent for improvement in steam boilers.

294th.—Mr. Sealy, of New York, invented a mode of destroying bugs by steam : this consists in a boiler with a spout, set on a chafing dish, and the steam is directed to crevices where the bugs are found.

1824.

295th.—John Mc. Cundy, of London, patent for an improved method of generating steam, communicated by a foreigner.

296th.—William Busk, of London, patent for improvements in the means or method of propelling ships' boats, or other floating bodies.

297th.—Philip Taylor, City Road, Middlesex, patent for certain improvements on Steam Engines.

298th.—John Christie, of London, and Thomas Harper, of Tamworth, patent for an improved method of combining and using fuel in stoves, furnaces, boilers and Steam Engines.

299th.—Jacob Perkins, London, 6th patent, for certain improvements in propelling vessels.

300th.—William Wigston, of Derby, patent for certain improvements in Steam Engines.

301st.—James Nivell, Southwark, and William Busk, patent for certain improvements in propelling ships, &c.

302nd.—J. Callier, of Paris, patent for an apparatus, to feed with coals, and other combustibles, Steam Engines.

303rd.—G. Danre, of Havre, patent for a steam boat to carry shell fish from Cancale to Saint Malves.

304th.—L. A. Delangre, of Paris, patent for a mode for propelling vessels and boats on rivers, by means of Archimedes' screw, placed horizontally, and put in motion by a Steam Engine.

305th.—A. A. Geerault, of Paris, patent for a system of oars, moving in a vertical direction, applicable to navigation of steam boats.

306th.—L. A. G. Hallette, of Arras, patent for a travelling Steam Engine.

307th.—J. Hanchett, Versailles, patent for an application of the re-active power of water, to put in motion boats, and vessels of all kinds.

308th.—G. Heath, of Paris, patent for a method of keeping a boiler always full of water, by condensing the steam.

309th.—Revon and Moulimee, patent for a Steam Engine, adapted to carriages of all sorts, and boats of all dimensions.

310th.—Walter Foreman, Com. R. N. of Bath, for certain improvements in the construction of Steam Engines.

311th.—Pierre Alegne, of Spain, and Commercial Road, Middlesex, patent for an improved and more economical method of generating steam, applicable to engines, and other purposes.

312th.—Henry Maudslay, and Joshua Field, of Lambeth, Surrey, patent for a method and apparatus for continually changing the water used for boilers in generating steam, particularly applicable to the boilers of steam vessels making long voyages, by preventing the deposition of salt, or other substances contained in the water; at the same time retaining the heat, saving the fuel, and rendering the boilers more lasting. A particular account of Messrs. Maudslay's engine and boiler, will be found in the first Chapter, and a plate of the machinery.

313th.—David Gordon, of Basinghall Street, patent for carriages to be propelled by steam, or other mechanical means.

314th.—Alexander Tilloch, of Islington, patent for an improvement in the Steam Engine, or in the apparatus connected with it.

315th.—J. Lausins, and A. Thayer, of Albany, New York, patent for an improved rotatory Steam Engine.

316th.—Thomas Hatton, Philadelphia, patent for an improvement on the Steam Engine.

317th.—Timothy Burstall, of Southwark, and John Hill, of Greenwich, patent for a loco-motive, or steam carriage, for the conveyance of mails, passengers, and goods.

318th.—Samuel Brown, of Saville Street, London, Com. R. N. patent for a new invented apparatus, for giving motion to vessels employed in inland navigation: this consists of a chain or rod of great length, applied to a Steam Engine in a boat.

319th.—William Gilman, of Middlesex, patent for certain improvements in generating steam, and on engines worked by steam, or other elastic fluids.

320th.—John Broomfield, Islington, near Birmingham, patent for certain improvements in machinery, for propelling vessels, which are also applicable to other useful purposes.

321st.—Goldsworthy Gurney, of Argyll Street, London, patent for his new invented apparatus for propelling carriages by steam on common roads or railways, 14th May. The boiler and engine are fully described in the first Chapter.

322nd.—J. C. Dretz, of Paris, patent for an improved rotative Steam Engine.

323rd.—J. Fowler, of Paris, patent for a new steam generator.

324th.—J. Grancin, of Crefforn, France, new mechanism of steam boats.

325th.—W. H. James, Coburg Place, Birmingham, patent for certain improvements in steam boilers, for Steam Engines.

326th.—John Thompson, of Westminster, and others, patent for improvements in producing steam, applicable to Steam Engines, &c.

1825.

327th.—W. Forman, Bath, patent for Scotland, for improvements in the construction of Steam Engines.

328th.—W. H. Hill, R. A. patent for Scotland, for improvements in propelling vessels.

329th.—J. Surrey, of Battersea, patent for Scotland, new method of applying heat to steam boilers.

330th.—John Maccurdy, Middlesex, patent for Scotland, improved method of generating steam.

331st.—Samuel Brown, of Middlesex, apparatus for giving motion to ships employed in inland navigation.

332nd.—William Franklin, of London, invented a self-acting feeder for high pressure boilers.

333rd.—John Reedhead, of Heworth, patent for certain improvements in machinery, for propelling vessels of all descriptions, in marine and inland navigation.

334th —W. H. Jones, notice that he has introduced a new invented generator for the steam carriage, he has a patent for, which he is of opinion will completely effect the purpose, and that he will not only be able to propel on a common road, but up a hill rising one inch in the yard.

335th.—Odica and Delivoni, of Paris, patent for propelling boats.

336th.—Granier and Tefort, of Paris, patent for apparatus to propel boats.

337th.—Giudicelli, of Paris, patent for improvements which he calls the "mechanical soul," to produce rotative motion by steam, &c.

338th.—Bourdiel, Desewnod, patent for apparatus to be applied to steam boats, to prevent the reaction of the water against the wheel.

339th.—De Mirmont, Vienne, patent for a process for propelling steam vessels.

340th.—S. Raymond, of Paris, patent for improvements in the Steam Engine.

341st.—R. Ort, of Paris, patent for propelling ships and boats.

342nd.—R. Richard, of Paris, patent for propelling ships against a current.

343rd.—O. Picquere de Siem, patent for a new rotative engine.

344th.—William Parr, Union Place, City Road, London, patent for improvement in the mode of propelling ships.

345th.—Charles Mercy, Middlesex, patent for certain improvements in propelling vessels.

346th.—William Jeffries, London and Radcliffe, patent for a machine for impelling with power, without the aid of fire, water or air.

347th.—Jean Antoine Teisser, of Middlesex, patent for certain improvements in the Steam Engine, communicated by a foreigner.

348th.—Lord Cochrane, for a new method of propelling ships and vessels. (This is understood to have failed.)

349th.—Josiah Easton, of Somerset, patent for certain improvements in locomotive engines, or steam carriage, and also in the manner of constructing roads and ways for the same to travel over.

350th.—Goldsworth Gurney, of Argyle Street, London, patent for his invention of certain improvements in the apparatus for raising and generating steam; a full account of this will be found in the 1st. Chapter.

351st.—Mr. Eve, of the United States, has given notice of his newly invented Steam Engine, which, he says, has less friction than any other. He took out his patent in November.

352nd.—J. C. Radatz, of London, patent for improvements on the Steam Engine.

353rd.—John Bloomfield and Joseph Lucock, of Birmingham, patent for improvements in propelling vessels, and other useful purposes.

354th.—John Mc Curdy, of Middlesex, patent for certain improvements in generating steam.

355th.—Vernet and Gauvin, of Paris, patent for a method of obtaining steam *without ebulition.*

356th.—Earnest Alban, of Rostock, patent for an apparatus to generate steam.

357th.—Samuel Brown, of Eagle Lodge, Brompton, addition to his patent for effecting a vacuum, and thereby producing powers disposable.

358th.—Samuel Money, Esq. of America, patent for a vapour engine, to be used in propelling vessels.

359th.—Marquis of Combo, of the Tower and Leicester Square, patent for a rotatory Steam Engine, and saving fuel.

360th.—Robert Mickleham, patent for improvements in steam or air engines, and saving fuel.

361st.—M. J. Brunel, London, patent for a new gas engine.

362nd.—John Thomson, of Westminster, patent for having invented and brought to perfection certain improvements in producing steam.

363rd.—Joanne Freres Dijou, of Paris, patent for a machine to drive boats by the power of steam.

364th.—Count de Martigiere, of Paris, patent for his invention of mechanism, to drive boats up a river he calls " Vatamont."

1826.

365th.—John Poole, of Sheffield, patent for certain improvements in the Steam Engine boilers and steam generators.

366th.—J. W. Long, U. S. Artillery, patent for a steam pump.

367th.—G. Duning, of Niagara, U. S. patent for a new Steam Engine.

368th.—William Barker, Kingston, U. S. patent for an instrument called a light gauge for a steam boiler.

369th.—Chauncey Crafts, Connecticut, U. S. patent for machinery for propelling boats.

370th.—William Robertson, of Craven Street, Strand, patent for a new method of propelling vessels by steam, on canals or navigable rivers, by means of a moveable apparatus attached to the stem or stern of the vessels.

371st.—Count Adolphe Eugene de Roseu, Princes Street, Cavendish Square, London, patent for his invention of a new engine to communicate power to answer the purposes of a Steam Engine.

372nd.—Joseph Browne Wilks, of Surrey, patent for his improvements in producing steam for Steam Engines, &c.

373rd.—Timothy Burstall, of Leith, 2nd patent for improvements in the machinery of locomotive engines.

374th.—Benjamin Philips, of New York, patent for steam boats to navigate in a shallow river.

375th.—Bennett Woodcroft, of Manchester, patent for certain improvements in wheels and paddles for steam boats.

376th.—B. Large, of Lyons, in France, patent for a system of boilers for Steam Engines.

377th.—John Castigan, of Callow, Ireland, patent for certain improvements in steam machinery and apparatus.

378th.—James Tandall, (at Mr. Hone's Manufactory, Warwick Street, London,) has obtained a patent for what he calls his calefier or refrigerator for condensing vapour, which deserves notice; it is on the principle of opposite currents, and may be seen at the Distillery of Messrs. Haworth and Co. Cloak Lane, Thames Street.

379th.—Jare Benedict, of New York, patent for relieving water wheels from the obstruction of back water.

380th.—S. Fairlamb, and D. Bruce, of New York, patent for a steam packet rotatory engine.

381st.—Stephen T. Corm, George Town, U. S. patent for a steam generator.

382nd.—Cotton Foss, of Ohio, U. S. patent for the application of steam to blast and other furnaces.

383rd.—Joseph H. Laning, of Tenasse, U. S. patent for a method of working steam twice over, or working two steam engines with the same steam.

384th.—Erskine Hazard, of America, patent for explosive mixtures to produce a vacuum, and thereby a power to propel by machinery.

385th.—James Frazer, of Houndsditch, London, patent for an improved method of constructing boilers of Steam Engines. By this method steam is got up with wonderful speed, and it is also very compact.

386th.—James Neville, of New Walk, Surrey, for his improved carriage propelled by steam.

387th.—Robert Barlow, Chelsea, patent for a new combination of machinery, or new motion for superseding the necessity of the ordinary crank in Steam Engines, and for other purposes, where power is required.

388th.—John Oldham, of Dublin, patent for certain improvements in the construction of wheels designed for driving machinery: also applicable to propelling boats and vessels.

389th.—Robert and James Stirling, Glasgow, patent for improvements in air engines, for moving machinery, &c.

390th.—William Stratton, of Limehouse, Middlesex, patent for improved apparatus for heating air by steam.

391st.—C. E. M. Bereche, Paris, patent for a lighter steam boat than those commonly built.

392nd.—C. E. M. Bereche, Paris, patent for a lighter steam boat than those commonly built.

393rd.—J. C. Dietz, of Paris, patent for a Steam Engine and water pump to propel vessels in canals and rivers.

394th.—A Goly Cazalat, and Captain Dubain, patent for an impelling power without machinery.

395th.—J. B. Dubost, Lyons, patent for a combination of Steam Engines, instead of horses to tow craft up rivers.

396th.—R. D. Carillion, Paris, for a Steam Engine with an inclined piston, stop, partial condenser, and metallic apparatus.

397th.—C. F. Derheims, patent for a particular method of constructing Steam Boats, in shallow rivers as well as in deep water.

398th.—H. H. Nery, Paris, patent for a Steam Engine, improved rotatory movement.

399th.—Thomas Peck, of St. John's Street, St. James, Clerkenwell, London, patent for his invention of the construction of a new engine worked by steam, which he denominates the revolving Steam Engine.

400th.—William Parkinson, of Barton upon Humber, and Samuel Crosley, of City Road, London, patent for an improved method of constructing and working an engine for producing power and motion.

401st.—Peter Bust, of Waterloo Place, Limehouse, London, patent for an invention of an improved Steam Engine.

402nd.—Minus Ward, of Baltimore, patent for a new and economical method of using heated air, gases, elastic fluids, and products of combustion, which are available to the increase of steam power.

403rd.—Elisha Bizelow, of Balesnore, patent for an improved Steam Engine.

404th.—Elisha Reid, of Lancaster, Kentucky, U. S. patent for a rotatory engine.

405th.—Daniel Phelps, of New York, patent for a steam generator.

406th.—W. F. Kearsing, of New York, patent for propelling boats.

407th.—Goldworthy Gurney, of Argyll Street, London, patent for certain improvements in locomotive engines, and other applications connected therewith. The description of these improvements will be found in the 1st Chapter of this treatise.

408th.—Andrew Motz Skene, of Jermyn Street, London, Lieut. R.N. patent for inventions or improvements in the mode of propelling vessels through the water, and for working under shot mills.

409th.—Paul Steinstreet, of Basing Lane, London, patent for certain improvements in propelling vessels, which improvements are applicable to other purposes.

410th.—John Lee Stephens, of Plymouth, Devon, patent for an improved method, or methods, of propelling vessels through the water by the aid of steam, or other means or power, and for its application to other purposes.

411th.—Thomas Sunderland, patent (1805) for a new combination of fuel, viz. $\frac{1}{3}$rd gas tar, $\frac{1}{3}$rd clay, and $\frac{1}{3}$rd saw-dust, should be mixed well and exposed for three months.

412th.—John Costigen, 2nd patent, 13th December, 1826, for certain improvements in steam machinery and apparatus. For a complete description of this improvement, I refer the reader to the Repertory of Arts, vol. 5th, pages 335, 385.

Any invention which will enable the high pressure engine to be used with safety, must be of importance to navigation, and the invention of Mr. Costigin appears to be one of those which obviates most of the objections which have been made; that of using horizontal cylinders is of much consequence, as it enables the machinery to be placed entirely below the water line; the contrivance to prevent the injuries which horizontal cylinders were liable to, from the friction and weight of their own pistons, is no less valuable than it is effectual and ingenious, and will, no doubt, be generally adopted in ships of war.

To the boiler there are, no doubt, objections, but these are not so great as to those in the common condensing engine now in use; unless a circulation of water can be constantly kept up in tube boilers, they will soon be destroyed by the action of the fire, though on Mr. Costigin's plan perhaps not sooner than in a common boiler, with the advantages of requiring less space, water, and perhaps less fuel, also of being easily cleaned and repaired, and constructed into any form suitable to the situation, and the expenses of fitting it up less. There is no doubt but this boiler will be much improved, and will, with other tube boilers, completely supersede those of the low pressure engine now in use. Mr. Costigin recommends placing the boilers and engines at a considerable distance from each other, and where the horizontal cylinder and buoyant pistons are used for propelling ships, he advises that the cranks should be longer than they are used at present, using also four cylinders instead of two, to work independently of each other, or in conjunction, as required, by which means one propelling wheel might be worked while the other is at rest, or if necessary propelling the opposite way to turn the vessel on her centre, and one cylinder could be used even if the rest were all out of order.

413.—Mr. Costigin is also the ingenious inventor of a method of impelling and guiding ships, by ejecting water from the stern, by which a moderate velocity may be given to a ship, and her broadside placed in any direction, even after her masts and rudder are gone, which, in many instances during last war, would have been of the utmost importance, the whole machinery being entirely below the water's edge. This consists in a small horizontal engine, on Mr. Costigin's plan, which works a force pump having two induction and two eduction nozzles, which can be directed and regulated at pleasure, so as to act upon the ship either by direct or lateral impulse. He mentions also a plan of applying compressed air to this purpose, but as the power of the steam engine, applied to propelling wheels or paddles, must supersede every such application of the power, it is unnecessary to give a detailed description of them in this treatise.

414th.—Mr. E. Galloway, whose patent in **1826** is already mentioned, has considerably improved his invention of a rotatory engine, for a description of which I refer the reader to the Repertory of Arts, vol. 5, p. 413.

415th.—Thomas Stanhope Holland, of London, patent for a combination of machinery for generating and communicating power and motion, &c.

412th.—William Hall, of Colchester, Essex, patent for certain improvements in propelling vessels, &c.

REMARKS.

Oldham claims having invented a new combination of those mechanical parts adapted to effect the revolving motions of the paddles, in the manner and by the means set forth in his specification.

Mr. James's boiler has been put to the test in pumping water, and is found with a two horse-power to raise seven hogsheads of water per minute, **13** feet high, at an expence of fuel of only 1s. 6d. per day; it is completely portable, and well suited to steam boats and locomotive carriages. The whole engine and boiler is contained in a frame five feet four inches by two feet, the cylinder of the engine has only three inches bore and one foot stroke, and is to be seen at Mr. J. Jones, Wells Street, Wellclose Square, London. The following is the inventor's account, which I believe to be correct.

The engine now at work, is the first constructed under the patent used; although it proves the value of the invention is capable of improvement, it works with more than two horses power. From the result of its operations during six months trial, it appears that an engine of the largest construction may be worked with less than one-half the expence of the best condensing engine; will occupy only one-tenth of the space, and be equal to only one-tenth of the weight. There is a considerable saving in the first cost, particularly in engines of great power, and will be found very desirable for fixed engines; for the purposes of navigation and loco-motion, it will be unrivalled.

Its advantages over common engines, are

Its perfect safety; which has been proved by the pressure of steam, to more than ten times its working power.

Its portability. The boiler and its suitable engine may be constructed so as not to exceed 2 cwt. to each horse power, for engines of 10 horse power and upwards.

Its space is not more than one-tenth of that necessary for ordinary engines.

The quantity of water (in proportion to a given power,) is less than that required by any other engine, in consequence of the steam after it is generated being expanded, by coming in direct contact with the flues.

Its saving in fuel is so considerable, that the cost in London would be less than ninepence per day, for each horse power.

And lastly, *The primary cost* will not be greater than that of engines on the ordinary construction.

Mr. Perkins's Steam Gun was made to project balls by steam at the enormous pressure of 110 atmospheres, and the result was, that they perforated a block of wood considerably further than those impelled by gunpowder ; a shower of balls was thrown at the rate of 1000 per minute, and Mr. P. maintains that he could keep up the same force of the steam without intermission for twenty-four hours, or any unlimited time. The experiments which have been tried, are said to have proved, that one pound weight of coal is capable of generating a quantity of steam equal in force to five pounds weight of gunpowder.

In the course of Mr. P's experiments, it is said, that he has discovered the cause of some of those destructive explosions of steam boilers, which have been hitherto inexplicable. He has found that steam may, under some circumstances, be very greatly raised in temperature, and at the same diminish in elastic force, but that elastic force may be communicated to it instantaneously. Consequently, a boiler in which water has entirely evaporated, may become red hot, and rarify the portion of steam remaining in it, without giving that steam any mechanical force, but on a sudden admission of a jet of water into the boiler, the steam will instantly take it up, and become of such exceedingly high pressure, as to cause explosion, and the destruction of the boiler.

1828.

George Jackson, of St. Andrews, Dublin, patent for certain improvements in machinery, for propelling boats and other vessels, also applicable to water wheels and other purposes.

William Nairn, of Dave Street, Edinburgh, patent for an improved method of propelling vessels, through or on the water, by the aid of steam or other mechanical force.

PARLIAMENTARY EVIDENCE.

1822.

On the 12th of June, 1822, a Select Committee of the House of Commons, took into consideration the subject of Steam Navigation, as relating to the communication between Great Britain and Ireland, when many of the best engineers, and most experienced in steam vessels, were examined. It appeared that the invention of paddles, and the application of the power of steam to a vessel, belonged to Jonathan Halls, who put his scheme in practice in 1736, using Newcomen's Atmospheric Engine; the next in succession was the Duke of Bridgewater, who used steam boats for towing barges: then Mr. Miller, of Dalswinton, constructed a double vessel, with a wheel in the centre between them. It appeared, that the Marquis de Souffroy, held a distinguished rank in the list of practical engiueers in 1781; he constructed a steam vessel at Lyons, 140 feet long, and made successful experiments on the Seine. In 1795, Lord Stanhope constructed a boat to be moved by steam; in 1801, Mr. Symington tried a steam boat on the Clyde. In the year 1807, the Americans proved by practice, both their safety and utility. But the merit of the American steam boats, is properly due to Mr. Henry Bell, who gave the first model of them to Mr. Fulton; he got the engines he first used from Messrs Boulton and Watt. In fourteen years, their numbers increased to above three hundred, and there were now more than double that number in

1811. The same year the Comet steam vessel, of only four horse power, was the first that appeared in Great Britain; she was constructed by Mr. Bell to ply on the river Clyde; the success of this experiment led to the construction of others of larger dimensions, which superseded her, and in a few years the rivers in both England and Scotland were covered with steam vessels of various descriptions; in 1818 they began to perform voyages by sea, and the Rob Roy was then established between Glasgow and Belfast; she was 90 tons burthen, with 130 horse power, and made her passage regularly in any kind of weather, long after it was impossible to get to sea in a sailing vessel, and establishing the fact that the steam engine could be extended to sea navigation. In 1819 the Talbot, of 150 tons, with two engines of 30 horse power each, plied daily between Holyhead and Dublin, encountering many severe gales; and in 1820 the Ivanhoe, of 170 tons, built by Mr. J. Scott, was established on the same station, their engines were both low pressure, and made by Mr. Napier, of Glasgow; and in 1821, notwithstanding much opposition, steam vessels were established as post office packets on that station. At this period the tonnage of the vessels and the power of the engines were increased, and began to carry passengers between Glasgow, Belfast, Dublin and Liverpool, and in the following year between London and Leith, Dover and Calais, and every direction along the coast of Great Britain and Ireland, placing beyond all doubt their safety in the most tempestuous weather. The trial at Holyhead also established that a packet could sail at a fixed hour, regardless of wind and tide, which could not take place with sailing packets, which are always obliged to remain either in a calm or a storm. The detail of the evidence of Captain Rogers, and other experienced seamen, who, even after the Talbot and Ivanhoe had been for months on the station, were obstinately of opinion that none but sailing vessels, such as the former packets, could ply with safety on that rough and boisterous channel during the winter months, is highly important, for the trial of that very severe winter, obliged them to change their opinion, proving on the very best authority, both the safety and superiority of steam vessels for that hazardous service.

Accidents of course occurred, naturally, from the novelty of the experiment, but they could always be traced to the ignorance or neglect of the persons employed in the management either of the vessel or the engine; to obviate which, low pressure boilers made of wrought iron or copper came into general use, so that if the boilers burst the materials of which they are composed, did not fly, but rent asunder; and many inventions to prevent fire were resorted to, so that danger from either cause was very much diminished, if not wholly removed. The Report then suggests that steam vessels should be compelled to carry a certain number of boats, but does not recommend any other restriction, conceiving that individual security would be sufficiently provided for, by the competition among the different proprietors. In this however, they have been much mistaken, for the proprietors who can sail their vessel at least expence, make the most by it, and they are often induced to use the machinery much longer than it ought, on account of making money, minding nothing but the velocity, which is always sure to obtain passengers, who are ignorant of the state of either vessel or engine; and the circumstance of their having boats sufficient to carry more persons than usual, only tends to induce them to run long after safety is doubtful. The average and comparative length of voyages are as follows.

	Steam Vessels.	Sailing Vessels.	Dist. Miles.
From Holyhead to Dublin, - -	8 hours	70 hours	55
Port Patrick to Donaghadee	3	8	19½
London to Leith - - - -	55	5 days	429

N. B. This passage was *once* made by the United Kingdom in 42 hours!

	Steam Vessels.	Sailing Vessels.	Dist. Miles.
From London to Dublin - - -	84 hours	16 days	610
Dublin to Liverpool - -	14	36 hours	131
*Greenock to Liverpool -	24	3 days	224
London Bridge to Calais -	12	36 hours	120
London to Margate - - -	8	20	84
London to Plymouth - -	38	10 days	315
London to Belfast - -	110	18	725
London to Ostend - - -	12	24 hours	90
London to Texel - - -	22	54	170
London to Scarborough -	25	68	225
London to Portsmouth - -	29	8 days	255
London to Hull - - - -	23	50 hours	215
Brighton to Dieppe - - -	9	30	73
Southampton to Havre - -	15	36	120
Ditto to Guernsey - - -	16	37	125
Milford to Waterford - -	11	25	81
Greenock to Belfast - - -	13	30	90
Greenock to Glasgow { up	3	12	24
Greenock to Glasgow { down	2½	6	
Greenock to Dublin - -	25	52	200
Greenock to Ayr - - - -	6	12	48
Greenock to Largs - - -	2	4	18
Greenock to Port Patrick -	9	20	90
Greenock to Isle of Man -	18	40	135
Greenock to Campbeltown -	16	18	67
Edinburgh to Aberdeen -	12	25	90
Edinburgh to Stirling - -	4	8	36
Harwich to the Helevoit Slys	13	28	90

* This passage was once made by the Majestie, in 21 hours, including one hour's detention at the Isle of Mann.

It was the opinion of the committee, that the application of steam to sailing vessels of the present construction, was impracticable; and that the first failure of steam vessels was also owing to the construction and insufficiency of the steaming power.

It was also collected from the evidence, that the accidents which occurred to the different parts of the machinery in steam vessels, had been owing to the ignorance and negligence of the engineers; viz. starting the engine without clearing the water, which is often formed above the piston from condensed steam, suffering the bearings of the shafts to work, the links connecting the piston and the beam to get loose, and in some cases making them too tight, so that they became hot by friction, and by not attending carefully to the valve when the vessel is exposed to a heavy sea. The late Mr. Watt said, "with "experience now obtained, we make no doubt but we shall be able to "construct machinery less liable to accident, much must always de- "pend on the vigilance and experience of the men who work the "engines." Mr. Brown, another eminent engineer, when asked what were the causes of accidents to the machinery, replied, "they depend "more on the engine keepers than any thing else." A long and desultory conversation is reported to have taken place with the engineers, Messrs. Bramah, Donkin, Brunel, Galloway, and Perkins, whose opinions varied as to size, strength, materials most proper, and the best construction of the boilers, which opinions are now not worth noticing, in consequence of the great improvements subsequently made in them. The evidence of Charles Williams, Esq. went to show that steam vessels behaved well in a heavy sea, and that the invention of *revolving paddles* by Mr. Oldham, was an advantage.

1st. That their action on the water is less violent.

2nd. They cause the engines to work more smoothly, at the same time doing the work more effectually.

3rd. They are of advantage when the vessel heels over by a press of sail, which others are not.

4th. They are of great assistance in tacking or performing any evolution.

5th. The draft of water is of little consequence, therefore steam ships which carry cargoes may load deeply without lessening the action.

6th. In case of accident to the engine the revolving paddles can be placed edgeways, so as not to hold water, and impede the vessel's progress.

7th. The revolving paddles cause no loss of power in striking the water as they enter or rise out of it, and they impel faster than common wheels.

8th. The revolving paddles do not require so large an external projection or sponcing as common wheels do, consequently they are easier for the ship.

9th. Vessels with revolving paddles are enabled to employ engines of a higher power with greater safety, and with speed commensurate, more than can be done with common wheels; vessels with the common paddle wheels certainly cannot set on the full power when running before a heavy sea, because they would sometimes be out of the water, and run round with great velocity two or three times, then plunging into the water be suddenly stopped, which is dangerous for the machinery.

Many inventions for paddle wheels have lately been brought out, a description of which will be found in another part of this treatise.

STEAM NAVIGATION ACT.

Abstract of an Act to facilitate intercourse by steam navigation, between the United Kingdom and the Continent, and the islands of *America* and the *West Indies*, 22nd June, 1825.—7 Geo. IV. cap. 167.

Clause 1st—Enacts, that a Company shall be established by the name of the "American and Colonial Steam Navigation Company," and to consist of Valentine, Earl of Kenmure, V. A., Sir Pultney Malcolm, R. A., Sir H. Blackwood, and seventy-two others, whose names are mentioned, as joint stock sharers.

Clause 2nd—Gives power to the said company to build, equip, fit up, and hire, ships and vessels, for supplying and providing fuel and materials, &c. also for making Steam Engines and machinery, to hire masters, pilots, engineers, seamen, mariners, and other men necessary, navigate such ships and vessels between the harbour of Valentia, in the County of Kerry, and such other ports, harbours, rivers, or places belonging to His Majesty in Europe, to other places of or belonging to His Majesty's dominions in America, and His Majesty's Colonies, as the Directors shall think fit, to contract for conveying and carrying passengers, emigrants, troops, military and other stores, goods and merchandize, to make wet and dry docks, provide wharfs, warehouses, erect buildings, and re-let or sell the said tenements, &c. provided the said company do not at any one time purchase, hold, or possess more than six statute acres of the surface of soil, which might subject the company to the penalties of Mortmain, or other law or statute.

Clause 3rd—Provides that every lease shall be for five years at least, to be executed by five directors, and the counterpart to be delivered, shall be binding and conclusive on all subsequent directors.

Clause 4th—Provides that the said directors shall find good security for the due performance of any contract or agreement entered into by them, and they shall also be personally responsible to the persons contracting.

Clause 5th—Provides that actions may be instituted and defended in the name of one or more of the directors, and in foreign colonies in the name of a director, or the agent or attorney for the said company, and the death of the said director, agent, or attorney, shall not abate the law suit.

Clause 6th—Provides that it is lawful for the Court of Equity to issue process of distringas or sequestration on the goods, chattels, and effects of the said company for contempt, and they shall be retained until such contempt is cleared, &c.

Clause 7th—Provides that the directors shall have power and authority to reimburse themselves, severally and respectively, for loss, damages, and expences which they or any of them shall bear, sustain, or be put to by reason of any matter or thing to arise or happen in the execution of this Act out of the funds and property of the said company.

Clause 8th—Provides that it shall be lawful for five of the directors to appoint persons to act as agents or attornies in His Majesty's colonies, and places aforesaid to be resident therein, and to revoke and recall them as occasion may require; and by them the said company may either sue or be sued, plead and be impleaded, at law and in equity. Provided such agents are appointed by five of the directors, and the same duly recorded and enrolled in the supreme court, and such record shall be deemed good and sufficient evidence of their appointments; provided also that such appointments shall be revoked or recalled, an entry of revocation or recalling shall be duly recorded in the county in which the appointment of any such agents shall be recalled or enrolled.

Clause 9th—Provides, that if any judgment or decree shall have been recovered or obtained by such agent in the colonies, it shall be lawful to prosecute the same in any of His Majesty's courts of law or equity in *Great Britain* or *Ireland.*

Clause 10th—Provides that a memorial of the names of the directors, in form of schedule, shall be enrolled on oath in the high Court of Chancery, in three calendar months.

Clause 11th—Provides that judgments, &c. in actions and suits against a director, are to extend to the property of the company.

Clause 12th—Provides that the vessels, &c. are to be inspected by persons appointed by the Secretary of State for the War and Colonies.

Clause 13th—Provides that a sum, not exceeding six hundred thousand pounds, shall, when paid in, be considered as a capital or joint stock, and that it shall be divided into shares of one hundred pounds each.

Clause 14th—Provides that the sums subscribed for the profits and advantages thereof, shall be deemed personal estate.

Clause 15th—Provides that three-fourths of the said capital are to be raised before any powers of the Act can be exercised.

Clause 16th—Provides that the company shall not borrow money, or raise it in any way but by subscription.

Clause 17th—Provides that before the directors shall commence any works hereby authorized, they shall invest, and continue invested, the sum of £10,000 in parliamentary funds, and continue to increase it until it amounts to £20,000.

Clause 18th—Provides that persons who have subscribed neglecting to comply with calls, are liable to be sued for the same in the name of the secretary, or by one or more of the directors.

Clause 19th—Provides that calls made on the subscribers shall not at any one time exceed twenty per cent. per share, and no calls can be made but at the distance of one month at least from each other, and notices of such calls are to be given in the London Gazette, and one or two London Newspapers; and if persons shall neglect or refuse to pay their proportion within thirty days after the time appointed, they shall forfeit their shares and interest in the undertaking, and the shares so forfeited shall be sold by the directors, after being three times advertized, not earlier than two months after the forfeiture.

Clause 20th—Provides that the names of the proprietors shall be entered into books kept by the secretary, and certificates of their shares delivered to them, but the want of such certificate shall not hinder the owner of a share to dispose of it.

Clause 21st—Provides for the security of persons holding shares in certain cases or circumstances, occasioned by deaths, marriages, bankruptcies, &c.

Clause 22nd—Provides for shares being transferred, and gives the form of transfer, which transfer must be registered, and the names of the parties to whom transferred entered.

Clause 23rd—Provides that no transfer shall be made until two months after the passing of this Act.

Clause 24th—Provides that the stock cannot be sold after a call is made, and due until the money is paid, and persons transferring before payment forfeit their share.

Clause 25th—Provides, that the Directors of the Company shall consist of eighteen qualified proprietors, two of whom shall be nominated as auditors of accounts.

Clause 26th—Provides that none but natural born subjects of Great Britain shall be qualified to be directors or auditors of the said company.

Clause 27th—Provides that an owner or proprietor of shares in the said company shall be qualified to be a director, if he shall at the day of election *bona fide* hold and possess, and continue to possess, ten shares at least of the joint stock of the said company, and he shall be in like manner qualified to be auditor or examiner, if he has held ten shares for the space of three months.

Clause 28th—Appoints by name the first directors and auditors, which it is now unnecessary to mention.

Clause 29th—Enacts that in February six directors shall go out of office in rotation, every three years.

Clause 30th—Enacts that six directors shall be elected out of the proprietors qualified, to succeed those who go out by rotation.

Clause 31st—Enacts, that the auditors and examiners shall go out annually.

Clause 32nd—Provides that officers may be immediately re-eleted.

Clause 33rd—Provides that in case of death, resignation, or want of qualification of the chairman, directors, or auditors, a special general meeting is to be convened by the directors of the proprietors to fill up such vacancy.

Clause 34th—Enacts the power of the Directors, to meet, adjourn, direct, manage, transact, issue, lay out, dispose of, build and equip, employ, make contracts and bargains, make bye-laws, rules and regulations, &c.

Clause 35th—Enacts that property or vessels registered under the navigation act, is vested for the time being in the directors, as trustees for the company.

Clause 36th—Gives power to the directors to appoint secretaries, bankers, receivers, collectors, engineers, surveyors, officers, clerks, agents, servants, &c. and to suspend or dismiss them.

Clause 37th—Enacts that the directors shall meet one day in each week at least, and at such other times as they shall think proper; that two of the said directors may call a meeting, five to be a quorum; in case of even numbers, the chairman to have the casting vote, and that no director shall be absent more than two months from his duty.

Clause 38th—Enacts that the directors have it in their power to call a Special General Meeting, by giving twenty-one days notice by advertisement.

Clause 39th—Enacts that there shall be a General Meeting on the first Monday of every February, or within thirty days thereafter, at twenty-one days notice; in the absence of the chairman or his deputy, one of the directors, and in the absence of all the directors, one of the proprietors to be chosen chairman, at which all questions are to be decided by a majority of votes of the proprietors, or their proxies; that is to say, one vote for two shares, two votes for five, three for ten, four votes for twenty shares.

Clause 40th—Enacts that no business shall be transacted at any Special General Meeting, besides the business for which it has been called, nor at any adjourned special or general meeting, except that is unfinished; nor shall business begin till one hour after the time of meeting, and due notice shall be given of the adjournment, to the proprietors respectively, or in the manner directed in this act.

Clause 41st—Provides that the directors are required expressly to present to the general meeting held in the month of February, a statement in writing of the debts, credits, and effects of the company.

Clause 42nd—Enacts that the proceedings of every general and special meeting, shall be entered by the secretary, or whoever acts as such, in a book or books kept for the purpose; and that such orders and proceedings so entered, are to be signed by the chairman, deputy chairman, or director or proprietor who shall be in the chair; and shall be deemed as original orders, and shall be allowed to be read before all courts, judges, justices, and others.

Clause 43rd—Enacts that ten or more subscribers holding together one hundred shares, can call a general meeting of subscribers or proprietors, for the purpose of taking their opinion and determination on any matter relating to the company; first, by requisition to the directors through the secretary, and secondly, on the event of a refusal, they may call a special meeting by advertisement in the *London Gazette*, and in four or more of the newspapers published in London or Westminster, stating the time and place, at least twenty-one days after the date of such notice; and the decision, determination, or order of the subscribers and proprietors present at such meeting, or a majority of them shall be valid to all intents and purposes.

Clause 45th—Enacts that every female who is possessed of two or more shares, shall be entitled to vote at any general meeting; and any proprietor who shall be actually resident at a greater distance than five miles from the place of meeting, may have full power and authority to give their votes by proxy, every proxy being a member of the company and entitled to vote.

(Here follows the form of Appointment.)

provided that the said form does not bear date at a longer period than six months.

Clause 46th—Provides that it shall be lawful for the said directors to declare a dividend, and to set apart one-fifth of the clear profits and produce, until that fund shall amount to £3,000 to meet contingencies, and that stock shall be replenished at every subsequent meeting when it is required.

Clause 47th—Enacts that general meetings may make bye-laws, provided they are not contrary to the directions or provisions of this act; and copies of them are to be printed, fixed, and continued in the office of the said company.

Clause 48th—Enacts the service of notices, writs, or other legal proceedings, upon any clerk, officer, or agent of the company, shall be deemed a sufficient service, or left at his last and usual place of abode.

Clause 49th—Enacts that the costs, charges, and expences to this act, shall be paid and discharged by the directors, out of the monies subscribed.

Clause 50th—Provides that this act shall be deemed to be a public act, and shall be judicially taken notice of as such, by all judges, justices, and others, without being specially pleaded.

In the year after the above act had passed, it appeared that a great number of the subscribers were unwilling to hazard their capital in this undertaking, and wished to withdraw their names from the list, to authorize which, and for some other purposes, the following act was obtained.

7th Geo. IV. cap. 124.

An act to amend an act of the last session of parliament, for facilitating the intercourse by Steam Navigation between the United Kingdom and the Continent, and Islands of America and West Indies.—May 26th, 1826.

Clause 1st—Repeats the preamble of the first Act, that £10 per share had been deposited, but that certain subscribers wish to withdraw from the company and receive back the residue of their deposits, and it being expedient that they should be permitted to withdraw; it is unnecessary to set apart one-fifth, and therefore expedient that it should be repealed; it is also expedient that the capital should be divided into £50 shares; also expedient that the directors should be authorized to purchase ships and register them, also to purchase provisions. But as these purposes cannot be effected without the aid and authority of Parliament, the said Act is altered and amended to enable the said subscribers to withdraw according to the form of certificate, (here follows the form of notice,) giving notice that by virtue of this Act the subscriber wishes to withdraw his or her name at the expiration of six months, after which it is enacted that he or she shall not be liable to any demand or claim as a member of the said company, nor entitled to future benefit.

Clause 2nd—Provides that the subscriber is liable for all demands and claims until the expiration of the six months, and is not discharged from the liabilities of the company, previous to his ceasing to be a member.

Clause 3rd—Enacts that in six calendar months after the passing of this Act, or as soon as possible thereafter, accounts and estimates of the company's property and debts are to be made out, which, when audited, are to be left at the office for inspection, on Tuesdays and Saturdays.

Clause 4th—Enacts that no payments are to be made to the proprietors that withdraw, until all liabilities of the company are discharged.

Clause 5th—Enacts, that so soon as the debts and engagements of the company are paid and the property turned into money, the directors may pay off the retiring proprietors their proportion of the residue which may remain of the deposits, after deducting the losses and expenses of the company.

Clause 6th—Enacts that a general meeting of the company shall be called at the expiration of six calendar months after the passing of this Act, when the debts, liabilities, and any engagements have been paid, to put into effect the purposes of this Act.

Clause 7th—Enacts that the directors are to cause a general account to be prepared and audited, and laid before the said meeting, signed as the Act directs.

Clause 8th—Enacts that the general meeting shall ascertain the amount of losses and expences to be charged against each £100 share, and the determination of this meeting shall be binding and conclusive on all parties.

Clause 9th—Enacts, that after this meeting the money due to the subscribers who have withdrawn may be paid, after the deductions have been made.

Clause 10th—Enacts that it shall be lawful for the said directors, in order to raise and make up the said capital, or joint stock, at any time or times hereafter to accept subscriptions from any person or persons who may think proper, of any share or shares of the said capital, and such person or persons, &c. shall be entitled to the share or shares in the capital of the said company for which his, her, or their subscription shall be accepted, and be a member or members of the said company, in the same manner to all intents and purposes as if the same share or shares had been subscribed for previously to the passing of the said recited Act.

Clause 11th—Enacts that the powers of this Act cannot be exercised if the payments and shares of the remaining members do not amount to £20,000.

Clause 12th—Enacts that after the expiration of six months the shares shall be £50 instead of a £100, and that the proprietors or their proxies shall be entitled to vote in respect of every £50 shares as fully as if he had held £100 shares under the said Act.

Clause 13th—Enacts that ships may be purchased, or vessels, for the purpose recited in the said Act.

Clause 14th—Enacts that the directors are to be trustees of the ships and property belonging to the company, and when it becomes necessary to register any ship or vessel belonging to the company, then the following oath shall be made by five or more of the directors of the company, and the register granted thereon. (Here follows the form of the oath.)

Clause 15th—Enacts that the one-fifth of the profits, as directed by the last Act, is to be repealed and set aside; and one-twentieth part of the profits to be set aside to answer contingencies, until the fund shall amount to £10,000.

Clause 16th—Enacts that the powers, provisions, regulations, directions, restrictions, matters, and things whatsoever, contained and recited in the first Act, except so far as any of them are expressly altered or repealed by this Act, shall be deemed, when and construed to extend and operate, and be in full force, with respect to all matters and things whatsoever which may happen and arise in the execution of this Act, as fully and effectually to all intents and purposes as if the same and every part thereof were repeated and re-enacted in this Act and made part thereof, and the said recited Act and this Act, to all matters and things whatsoever, except as aforesaid, be construed into one Act.

Clause 17th—Enacts that the costs, charges, and expences attending the applying for, obtaining, and passing this Act, shall be paid out of the monies or property belonging to the company.

Clause 18th—And it is lastly enacted, that this Act shall be deemed and taken to be a public Act, and shall be judicially taken notice of as such by all judges, justices, and others, without being specially pleaded.

I have given the above Abstract of two Acts of Parliament on the subject of the American and Colonial Steam Navigation Company which may *now* be said to be asleep, because I have no doubt but it will ere long be acted upon, to the great advantage of the nation, as well as to the proprietors. It will be a *nursery* for the very class of people which will be indispensible in time of war for the defence of the nation, and is an undertaking which ought to be encouraged by every affluent and patriotic individual, and will be of as much importance to the navy as the country trade has hitherto been; and when steam navigation has made a little more progress, this undertaking will certainly flourish.

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