IN SENATE OF THE UNITED STATES.

MARCH 2, 1840.

Submitted, and ordered to be printed.

Mr. RUGGLES submitted the following

REPORT:

[To accompany bill S. No. 247.]

The Committee on Commerce, to whom was referred the resolution of the Senate instructing them to inquire whether the law regulating vessels propelled in whole or in part by steam does not require amendment; and to whom were also referred sundry petitions and memorials on the same subject, submit the following report:

Against any supposed necessity for regulating steam navigation by law, with a view to a greater degree of security against accidents, it has been urged that the proprietors of steamvessels cannot be supposed to neglect any thing which would conduce to the safety of the public, since their own interest would also suffer from such neglect.

It has also been urged that masters, pilots, and engineers, having their own lives at stake no less than passengers, will never need the superaddition of legal penalties to stimulate their vigilance.

But steamboat proprietors are generally associated individuals who conduct their business by agents. Although it is for their interest to acquire and preserve the confidence of the travelling public by providing the means of safety, yet they are not to be supposed, more than other men, to overlook the matters of economy and profit. Besides, insurance diminishes their hazard, without abating that of the public.

Their agents have generally less at stake. They may be presumed sometimes to regard the amount of dividends as affording the best evidence of their good management; and it would not be strange if, in the pursuit of that object, they should often lose sight of, or underrate, the dangers which constantly surround the unwary traveller.

As to engineers, they are familiar with danger, and become insensible to it. If ignorant of their duties, or are of reckless character, little confidence can be reposed in their regard for their own personal safety.

We have had too many proofs of the futility of relying alone on the self-interest of proprietors, or the sense of personal hazard of engineers, for security against steamboat disasters. Legislative regulations and penalties must, therefore, interpose their protection.

This important subject has engaged the serious attention of other Governments. France, Holland, and Belgium, have adopted very strict regulations for the management of land as well as marine engines. To

France is due the credit of being the first to establish an efficient code of regulations in the detail for the government of steamvessels; the wisdom and efficacy of which have been demonstrated in her comparative exemption from steamboat accidents.

The British Government has several times had the subject under consideration, although, as yet, the travelling public in England is still exposed to all the hazards of a commercial steam-marine with little legal restriction or regulation. The consequence has been, the multiplication of accidents, and a long and increasing list of steamboat disasters. The necessity of legislative interposition at length became so urgent, that a commission was instituted in January, 1839, to make a preliminary investigation of the causes of such accidents, and to ascertain the best means of preventing them. This measure has resulted in the collection of a mass of interesting and valuable information, scientific, statistical, and practical, comprising all that is valuable in the experience of that country in steam-navigation.

The committee have selected and placed in an appendix to this report, such portions of that information as they believed would be most useful to builders of steamvessels and steam-engines, or to the owners and those who have the care of them, or are in any way interested in their safe management.

Steam-travel in this country has been attended with somewhat more hazard than in England. The ascertained and reported number of accidents in England being 92, while those of the United States amount to 272. The difference much exceeds that of the number of steamers employed.

Much of this difference of hazard arises from the peculiar casualties to which steamers are exposed on the Western rivers, from snags and sawyers, and from collision in fogs, or in turning short bends in the rivers. Something, too, may be placed to the account of that racing and reckless propensity, which is there subject to less rebuke even from passengers, than it meets with on the Eastern waters. Another reason for it, prolific of disaster, is to be found in the arrangement of the high-pressure boilers in the Western boats, by which the flues are more exposed to become bare of water and overheated while careening at the numerous stopping places. Out of the 272 ascertained accidents abovementioned, 207 have occurred on the Western rivers, and 65 only on the Eastern waters and the great lakes.

Memorials have for years been flowing in upon the Government, praying its interposition in this matter; and measures have been taken to collect information relative to the causes of accidents and the means of preventing their recurrence. In 1832, a special committee of the House of Representatives, after much investigation, reported a bill for the regulation of this species of navigation. But it was not until 1838 that any law on the subject was passed by Congress, although the States of New York and Louisiana had long before found it necessary to adopt legislative regulations for boats running in their waters.

The act of Congress referred to, has undoubtedly contributed, in some degree, to the public security; but we have abundant proof that it falls far short of effectually shielding the public from those disasters which prompted its adoption. Within the last year about 200 lives have been lost by the causes complained of, exceeding the average of former years.

There were 41 accidents in 1839 on the Western waters alone. The following statistical account of them is derived from a Western publication:

Snagged	21
Struck upon rocks, &c.	7
Destroyed by fire	6
Explosions	4
Collisions	3
Whole number	41

Of these, 23 were totally lost. Loss of property estimated at not less than a million of dollars.

Lives lost by explosions	39
By other causes	7
	46
Snagged on the Lower Mississippi,	11
on the Missouri	4
on the Ohio	4
on the Yazoo	1
on the Red river	1
	21

It is spoken of as remarkable that a majority of the boats were snagged on their downward trips.

Add to these the loss of the Great Western, by fire, in Detroit river, a new boat, built at a cost of $100,000; the accident on board the Narraganset, on Long Island Sound, in August last, by which several persons were severely scalded (App. C); the loss of the Lexington, by fire, on the Sound, by which about 150 lives were lost (App. B); the collapse of a flue of the Erie, on the Hudson river; which, with a few other accidents of less moment, including many fires that were extinguished, but not particularly ascertained, make up the sum of last year's steamboat misfortunes, and furnish ample reason for some more effective legislation.

The following numerical abstracts will serve to show the comparative hazard attending the employment of steam in the British steam-marine; and in steamvessels of the United States, so far as it has been ascertained:

Abstract of 92 accidents to the British steam-marine.

No. of vessels.		No. of lives lost.
40	wrecked, foundered, or in imminent peril	308
23	explosions of boilers	77
17	fires from various causes	2
12	collisions	66
92		453

Computed number of lives lost on board of the Erin, Frolic, and Superb 120

Lost in the Thames, exclusive of the above, during the last three years	40
Lost in the Clyde, in Scotland, during the last ten years	21
	634

Greatest number of lives lost at any one time by wreck of vessels (The Rothsay Castle)	119
Greatest number at any one time from collision	62
Greatest number from explosion	24
Greatest number from fire	2

Of the 23 explosions ascertained, there occurred:

In cylindric boilers	7
In rectangular boilers	15
Not ascertained	1
	23

19 explosions happened while the vessels were stopping, or on the instant of setting the engines in motion.
3 ditto, while steaming.
1 not ascertained.

23

Abstract of 272 steamboat accidents in the United States.

No. of vessels.		No. of lives lost.
103	explosions and collapse of boilers	886
73	striking on snags and sawyers	118
35	shipwrecks, gales, and collisions	473
34	fires from various causes	444
27	unascertained causes.	
272		1,921

The returns show about 450 wounded.

Greatest number of lives lost at one time *by explosion:*

On the Pulaski, coast of Carolina, in 1838	138
On the Oronoko, in the Mississippi, in 1838	130
On the Moselle, Ohio river, in 1838	120

Greatest number *by collision:*

On board the Monmouth, on the Mississippi, in 1837	300

Greatest number by *fire:*

The Lexington, in Long Island Sound, January, 1840, about	150
The Ben Sherrod, in the Mississippi, 1837	130

Greatest number by *foundering:*

The Home, on coast of Carolina, 1837	100

Of the 272 accidents, there occurred on the Western rivers	207
On the Eastern waters and the lakes	65
	272

The Secretary of the Treasury, in his report to Congress on this subject, of December 13, 1838, which furnishes a great portion of the data for the foregoing statistics, estimated the loss of property by steamboat accidents at from five to six millions. It may now be estimated at from six to eight millions.

The steam-tonnage of the United States, registered and enrolled September 30, 1839, is as follows (see table in Appendix):

	Tons. 95ths.
Employed on the Northwestern lakes	18,341 27
Employed on the Eastern waters	54,473 59
Employed south of the Potomac river	17,831 15
Employed on the Western rivers	108,923 58
Whole amount	199,569 64

Estimating the average of boats at 200 tons burden, the whole number of steamboats registered and enrolled would be 1,000.

How many there are of a smaller class, not included in the above, employed as ferry-boats, and in other local service in harbors, or as tow-boats, we have no data from which to estimate.

The computed or estimated amount of the power of the engines employed is 70,000 horse-power. This estimate is probably below the actual amount.

The approximate number, tonnage, and steam-power of the British mercantile steam-marine is as follows:

		Tonnage.	Computed horse-power.
No. of vessels registered in 1838	677	131,080	54,361
Not registered	83	9,638	2,129
Total in Great Britain and Ireland in 1838	760	140,718	56,490
Islands of Guernsey, Jersey, and Man, 1837	6	1,450	600
British colonies, 1837	44	15,664	6,160
Total	810	157,832	63,250

The following classified enumeration of the causes of accidents to steamvessels, will serve to indicate the character of the necessary measures of precaution to be adopted, and direct the application of appropriate remedies:

Explosions, caused by—

1. Bad construction of boilers in respect to form, and being insufficiently stayed.
2. Unsuitable materials used in their construction, and bad workmanship.
3. Using old boilers after being weakened by being corroded, burnt, or strained.
4. Want of sufficient safety-valves, in number and area.
5. Overloading safety-valves on an erroneous estimate of the strength of the boiler.
6. Ignorance, carelessness, recklessness, and drunkenness, of enginemen and firemen.

7. Suffering the water to get too low in the boilers, from inattention or want of apparatus to denote the level of the water and the temperature of the steam.

8. Want of steam-gauges, or errors in their indication.

9. Inattention to frequent cleansing of boilers of saline and muddy deposites.

Fires, caused by—

1. Placing boilers too near the decks, partitions, and sides of the vessel, without defences of sheet-iron, or lining of boiler-room; and having brick walls or other slow and constant conductors of heat, resting on or against the woodwork.

2. Want of protection to the decks from overheated flues and chimneys; and defects in the flues, or at the junction of flues and smoke-pipes, occasioned by burning or rusting.

3. Fire being blown out of the furnaces into the fire-room, among the fuel and other combustibles.

4. Stowing fuel in the fire-room, and too near the boiler.

5. Dangerous stowage of combustible merchandise, and sparks from the chimney.

6. Incautious using of lights in the private apartments.

7. Deficiency of means of extinguishing fires; and panic and confusion from the consciousness of such deficiency, without boats enough to insure escape.

8. Want of faithful fire-watch.

Wrecks, *snagging*, and *foundering*, caused by—

1. Failing of defective boilers and engines.

2. Frail and defective hulls.

3. Want of water-tight bulkheads.

4. Deficiency of sails, and want of cables and anchors.

Collisions, caused by—

1. Want of proper signal-lights.

2. Want of a gong or "steam-whistle," in fogs or thick weather.

3. Neglect to keep a lookout.

4. Want of a defined "rule of the road."

The only practicable mode of reaching these causes of disaster, is by means of a compulsory, rigid, scrutinizing inspection of the hull, boiler, engine, and all the equipments of steamvessels, made by competent and sworn officers; not nominal and formal merely, as is too often the case under the present law, but an actual and faithful inspection.

For this purpose, it will be necessary to have inspectors appointed at the various places where the inspection is to be made; and they must have a compensation which will command the services of the most trustworthy and best qualified.

It is not to be presumed that men, entirely competent for this duty, can be found at all points. It is believed that there are but few places where such can be found; and the country is too extensive to admit of a superintending central board. It will be necessary, therefore, to prescribe and define by law, as far as practicable, the particular duties of the inspectors, and to determine and specify what equipments shall be provided for steamvessels, as being necessary to the public security.

To secure a faithful inspection, a penalty should be imposed for giving a false certificate, or for giving a certificate without making the inspection

required. Instances have occurred under the existing law, of certificates being given by the inspectors without going on board of the vessels at all, taking the word of the master that every thing is in good condition.

Such delinquency, in such a matter, is criminal in itself, and should be punished as such. But the law provides no punishment, not even the penalty of removal.

Structure of the hull.

In the zeal for acquiring speed, so much indulged at the present day, too little regard is paid to the strength and firmness of the hull. Very few American steamers are adapted to sea-navigation. They are generally too long, light, and frail, to encounter rough seas, or to sustain the severe shocks to which they are exposed, from collision and other causes. They should be inspected while building. The comparative length of keel and beam, the fastening, diagonal bracing, and "mutual interlocking, of all parts of the structure in contact," are matters too little attended to in sea-going steamers, and should claim the special consideration of the inspectors. River steamers are often transferred to coast navigation, for which they are not adapted.

In England the hull is often constructed of iron, and the advantages claimed for them are, that they may be made to draw less water, are more stanch, suffer less injury from striking on rocks, or being driven on shore, are less liable to take fire, and may be made more durable. In England they are also less expensive.

The materials for two or three iron-steamboats, have been imported from abroad, and one has been constructed at Pittsburg. From a conviction of their superiority in several particulars, it is believed that the interest of the country would be promoted by giving all practicable encouragement to their construction in the United States.

There is another point respecting the construction of the hull which is of much importance; making them with wrought-iron water-tight bulkheads (see Appendix, page 51). This would afford great additional safety, especially on the Western rivers where boats are so often sunk by snags and sawyers. With water-tight bulkheads, the sinking of a boat by snagging, it is believed, would be of rare occurrence.

Steam-boilers.

The only practicable mode of testing the strength of the boiler, is by hydrostatic pressure. The maker, it is true, can form some opinion of its strength, having a knowledge of the quality of the material used in its construction, and of the faithfulness of the workmanship. But the inspectors can know nothing of its secret defects, even when new, nor, especially, of its strength when deteriorated by age, overheating and straining. The forcing in of the rivets where the holes are punched cold, and not made to correspond with each other, is often a source of incipient weakness which is not visible to the inspector, nor can he ascertain it by any other test than that of interior pressure. The strength of the material is often unknown to the builder himself until it has been tested. Some boiler-iron, it is said, will not bear so great a strain as some other of equal thick-

ness, and of no better apparent quality, by seven or eight times its whole strength.

A test by hydrostatic pressure is not now required by law, and is, therefore, seldom, if ever, resorted to by inspectors.

One of the most fruitful causes of explosions, is to be found in the defective arrangement of high-pressure boilers, of which from three to eight and ten, are employed in generating steam for the same engine. They are placed side by side, connected by steam and water communications. When the boat careens, as at wood-landings and stopping-places, where the passengers usually rush to one side, the water leaves the more elevated boilers and runs into those on a lower level, exposing the upper sides of the fire-flues to the action of the fire. The flues become heated to redness, surcharging the incumbent steam to a dangerous degree, greatly disproportionate to its elasticity, and much above the temperature of the water. When the boat is trimmed again, the water flows back upon the heated metal, by which a great amount of steam of high tension is suddenly generated. In addition to this, the machinery being set in motion at the same time, the abstraction of steam for that purpose induces a rising of a portion of the water in foam or spray which is instantly converted into steam by the excess of heat contained in the rarified medium into which it is forced. The result of these causes combined, is but too well known and too often experienced.

To open the safety-valve in such cases at stopping-places, as required by the present law, without continuing to pump water into the boiler, tends to produce the very effect it was designed to prevent. It produces a more rapid exhaustion of the water below the flues, and diminishes the density of the steam without sufficiently controlling its temperature.

How often it has been stated of explosions, that just before they occurred, the steam-gauge indicated no more, and sometimes less, than the ordinary pressure. In such cases the water being worked too low, the steam becomes surcharged with heat, and rarified by a portion of it escaping. In this condition the pressure-gauge shows no more than the usual tension of steam, its elasticity being diminished, or at least not increased. It is thus that the engineer is deceived, being led to suppose from the gauge and the safety-valves that all is well, while the boiler is approximating the very point of explosion.

To this cause is attributable a very large proportion of all the explosions which have taken place on the Western waters where this description of boilers is almost exclusively used.

The obvious remedy for this evil, is so to form the water communications between the boilers, as to prevent the water from running out of the elevated boilers below a safe level, and to keep the supply-pump in operation.

Suffering the water to get too low, exposing the steam to an immediate contact with the heated flues, is supposed also to be the cause, in like manner, of four-fifths of all the explosions that take place in low-pressure boilers. This opinion is corroborated by a statement in the British report before spoken of; that of the twenty-three explosions which have occurred in English steamers, nineteen happened while the vessels were stopping, or on the instant of setting the engines in motion; three took place while steaming; one not ascertained. These are all supposed to be on the low-pressure principle, as none other are allowed to be used in the English boats.

Whether high or low pressure engines, are attended with the most danger, is a question not very well settled, except so far as that the failure of the high-pressure boilers, when it takes place, is usually attended with the greatest destruction and loss of life. The form of the boiler, however, is regarded as a matter of some importance; the cylindrical being less liable to accident than the rectangular. Of the twenty-three explosions above referred to, it appears that seven occurred in cylindrical boilers; fifteen in rectangular boilers; one not ascertained.

American statistics furnish no data for such comparisons.

Safety-valves.

It is now generally conceded by those best informed on this subject, that there ought to be two safety-valves to every boiler, one under the command of the engineer, the other inaccessible to him except to open it. To be effective they should be larger than are commonly used, and proportioned to the extent of fire surface. In other words, they should be of sufficient area to pass all the steam generated by the boilers in their ordinary working condition.

The French law requires two such valves; the high-pressure, loaded by means of a lever, the low-pressure, with a solid weight upon them. It also requires two disks of fusible metal (fusible valves) for each boiler, of different dimensions, fusible at different degrees of temperatture; one to equal the area of one of the valves, and the other four times that area (see Appendix).

Steam and water gauges, and thermometers.

These are important instruments. The mercurial steam-gauge detects any derangement or error of the safety-valves, and they in their turn detect those of the steam-gauge.

In high-pressure boilers generally, and often in those of low-pressure, reliance is had solely upon the common gauge-cocks, for ascertaining the height of the water: Owing to the foaming of the water, they often give false indications to the extent of four, five, and six inches. Experience and prudence dictate the application of one, if not two glass water-gauges to each boiler, or a well-arranged water-float with index denoting the level of the water in the boiler.

As auxiliary to these, and the steam-gauge, a thermometer is admitted to be an important instrument; the temperature of the steam, if saturated, indicating its corresponding tension. If the steam-gauge and thermometer do not, at any time, agree, the temperature mounting above the indicated pressure, it shows that the tops of the fire-flues are becoming bare, and the injection-pumps must be looked to without delay.

The regulations of France, in addition to the safety-valves and fusible metal valves, require two glass water-gauges to each boiler, a float with index, three gauge-cocks, and a mercurial steam-gauge. They also recommend a safety-pipe attached to the boiler, with a whistle at the end to give notice when the water is too low. The French regulations are more minute and definite than those of any other country, and accidents there very seldom occur.

Since pains and penalties alone will not always ensure the vigilance or fidelity of engine-men, especially without the means of detecting their

delinquency, it is recommended as a great additional means of safety, that the indications of the pressure and water gauges, be transferred to some public part of the boat for the inspection of passengers, by which means they can always know the height of the water, and pressure of steam under which the engine is working. That will not only give confidence and satisfaction to passengers, but will also induce more watchfulness on the part of engine-men, from the certainty of detection in case of neglect. It is always useless to impose penalties without some means of detecting delinquency.

Fire, and means of prevention, and of escape.

The particular causes of fire in steamboats have been enumerated. The less controllable and more destructive fires originate about the furnaces; the more frequent ones take in the decks, from the flues and smoke-pipes, or from falling sparks among combustible merchandise.

The deplorable destruction of human life arising from the conflagration of steamvessels, calls loudly for effective measures to prevent the recurrence of such calamities. It is remarkable that, while in England only two lives have been lost by the burning of steamboats, there have been near four hundred and fifty in the United States. The committee believe that this sacrifice of human life may be prevented; and it is becoming the power whose appointed duty it is, in its proper sphere, to protect the life and property of the citizen, to say emphatically that such disasters must cease. Surrounded with water, floating in the very element in which alone fire cannot exist, why is it that hundreds at a time, men, women, and children, are so often left in horror to choose between burning and drowning!

The remedy is plain; the means of prevention are abundant. All that is wanting is a compulsory law enjoining their application.

The most obvious of those means, are, making the boiler-rooms fireproof by a lining throughout of sheet-iron, and an under lining of sheet-lead in the wake of the boiler, protecting the decks around the smoke-pipes in a similar manner, and employing constantly a faithful fire-watch, especially in the night-time. To these measures of prevention, add the means of promptly extinguishing incipient fires, such as fire-engines, buckets with bailing ropes, and reservoirs of water on the decks; and, as a last resort, let there be boats enough to save passengers and crew.

Without any such provisions, the cry of fire is doubly appalling, and no one can wonder that a scene of confusion and general panic ensues. But let those means be provided which afford a reasonable expectation of subduing the flames, or, in case of failure, ample means of escape, and all would go calmly to work to put out the fire.

Safety-boats.

In sea and lake going vessels, the safety-boats should be of sufficient capacity to carry all on board. It is a singular error to provide the means of escape from a vessel on fire or from shipwreck, for some of the passengers and not for others—for a part, and not for all. Insufficient boats are worse than none at all. In the contest for life—the struggle to see who shall be saved and who not—the boats are almost inevitably swamped, and

all are lost. Without any boats to contend about, the passengers would at once turn their attention to subduing the flames.

The objection that the decks would be too much encumbered by safety-boats of the required capacity, is obviated by the great buoyancy and lightness which recent improvements have given to the life boat. Francis's life-boats especially, as recently improved, possess very great buoyancy and capacity; and evidence has been laid before the committee, which satisfies them of their superiority and usefulness, and that they are entitled to all the commendation which has been bestowed upon them (see Appendix, page 26).

Engineers.

However thoroughly steamvessels may be equipped and provided, the public can have no assurance of safety without skilful, moral, and vigilant engineers. In one sense, they have the lives of all on board in their keeping, even more so than the master himself. This high responsibility demands qualifications not always met with in that class of officers. A faithful discharge of their duties requires a practical as well as theoretical knowledge of the nature and properties of steam, and of the mechanism used in its application. They must not only fully understand these matters, but also be capable of feeling a deep consciousness of the importance of their station. They should be men of sobriety and moral worth, and be influenced by self-respect and pride of character, without which they can entertain no just appreciation of the trust confided to them.

The latter qualifications should be possessed also by masters and pilots; and masters should, moreover, and especially, be capable of maintaining self-possession in time of alarm, to enable them to act with coolness, as well as promptness and energy. One who has not self-command, is unfit to command others.

It is not to be disguised, that, in some sections of the country, if not in all, a great reformation has become necessary in the character and qualifications of steamboat-engineers. To this grade of officers must be given a more elevated character and standing, one that will command confidence in their trustworthiness. This object can be attained in no other practicable way than by establishing and applying to them the examination and licensing system, and compelling proprietors of steamboats to employ for engineers the best, not the cheapest; whereas, now, the cheapest are often preferred to the best.

If there are not enough possessing the requisite qualifications to man all the engines afloat, the tendency of the provisions recommended will be, to increase the number by improving and elevating the character of that profession. In that, as in every thing else, the supply will accommodate itself to the demand.

Summary of the provisions recommended to be made by law.

1. Steamvessels not allowed the privilege of enrolment or registry without a certificate of inspection, and payment to the collector, if the vessel be under one hundred tons burden, of $10; if between one and two hundred, $15; if between two and four hundred, $20; if over four hundred, $30.

2. A system of compulsory, thorough, and faithful inspection of the hull, boiler, machinery, and all equipments of the vessel and engine, to

be made by inspectors appointed by the district judges, and to hold their appointment four years, unless sooner removed.

3. Inspectors empowered to examine witnesses under oath on the construction of the hull and engine, and touching any matter of which it is their duty to inquire; to discriminate between vessels adapted to lake and sea, and those adapted only to river navigation; to inspect the hull annually; to test the boilers by hydrostatic pressure semi-annually, and oftener, if necessary; may examine, on request of passengers, and to certify positively the results of their inspection; to determine and certify the maximum pressure to which the steam may be raised, not to exceed one-third of the test pressure; and also, the minimum height of water, below which it may not be exhausted; to notify when a vessel becomes unsafe to transport passengers; to examine and license engineers, annually, and to revoke licenses for intemperance, neglect of duty, or misconduct; to report, annually, to the Secretary of the Treasury the number of steamvessels inspected, and the particulars of their equipments and condition, and particulars of accidents; to receive from the collector of the district $20 for the annual inspection of each vessel and equipments, and $15 for all other inspection of each during the year, and to receive from each engineer examined $5.

4. Steam-boilers to be tested at three times the pressure allowed as a maximum; the boilers to be provided with a mercurial steam-gauge, thermometer, and glass water-gauge, or a water-float, protected by a curb, from agitation and foaming, with index showing the height of the water; gauge-cocks to communicate with a tube within the boiler; boilers to have two safety-valves of approved area, one to be inaccessible to the engineer, except to raise it, to be loaded by the inspectors at the maximum pressure, the other at halfway between the maximum and the common working pressure.

5. The indications of the steam and water-gauges to be exhibited in view of the passengers, in a conspicuous part of the vessel, showing, on a scale, the pressure of steam and height of water the engine is working under.

6. Hand force-pumps for injecting water into the boiler on failure of engine-pump, or obstruction in the injection-pipe.

7. The boiler-rooms to be made fireproof inside by a lining of sheet-iron, forced half an inch or more from the woodwork; the decks around the smoke-pipes to be similarly protected.

8. Steamers to have two or more effective fire-engines, double force-pumps, or rotary pumps, one on the forecastle and another aft, drawing water by suction-pipes through the bottom of the vessel, and hose to each to convey water to any part of the vessel; also, forty buckets, with bailing-ropes attached; and axes; and two or more tanks on promenade-deck, holding not less than three hundred gallons, to be kept filled with water.

9. Lake, sound, and sea going steamers, to have an equipment of sails; and safety-boats sufficient to carry all the passengers and crew, one-half, at least, in capacity, to be life-boats. River steamers under one hundred and seventy-five tons, to have boats to carry at least forty persons; over one hundred and seventy-five tons, boats to carry seventy persons.

10. Metallic tiller-chains or rods to be used instead of ropes, except so much as passes around the tiller-wheel; the chain to be capable of being disengaged at the stern; and a spare tiller to connect with the head of the rudder-post.

11. At night a white light to be elevated forward, and a red light aft; the former twelve feet above the upper deck, the latter three feet lower: to have a steam safety-pipe, to be sounded every half minute in fogs or thick weather.

12. As "a rule of the road," steamers meeting "stem on," to starboard their helms, and pass to the left, except that in rapid rivers, the ascending steamer shall have the preference of the inshore slack water and eddies; the descending steamer the preference of the current. Steamingvessels meeting sailing-vessels, to pass to the windward, yielding the course and giving good berth to the sailing-vessels, whatever may be the direction of the wind.

13. Engineers to be of two classes, chief engineers and sub-engineers; to have license from the inspectors, after examination into their competency and skill, sobriety, and good moral character; none others to be employed. Every boat to have one chief engineer, and a competent number of sub-engineers. Certificate of inspection, and of examination of engineers, to be posted up on board.

14. Sea, sound, and lake going steamers, not to carry gunpowder. Steamers on rivers emptying into the Gulf of Mexico and their tributaries, not to carry gunpowder except in iron chests, and notice thereof to be posted up on board.

15. The putting on board of any sailing-vessel or steamvessel, gunpowder, secreted in other merchandise, disguised, or falsely marked, or without information to the master, to be punished as a misdemeanor, and powder forfeited.

16. Inspectors punishable for giving certificate without examination, or for certifying knowingly what is not true.

17. All duties enjoined to be enforced by penalties.

18. Any person employed on board of steamboats by whose negligence or misconduct the life of any passenger shall be destroyed, to be considered guilty of manslaughter, and punished by imprisonment.

19. For carrying excess of steam, or working the water below the point prescribed, penalty and forfeiture of wages.

20. Owners and masters to be considered as common carriers, and liable as such; and all agreements and notices to the contrary made void.

21. The fact of injury to person or property on board by steam, fire, or collision, to be *prima facie* evidence of negligence; and owners liable for the wilful misconduct, as well as negligence of those in their employment.

A compliance with regulations of the foregoing description, cannot be attended with great expense to the owners of steamvessels; certainly in no degree commensurate with the advantages to be derived in the security they will afford to human life. The proprietors themselves, it is believed, will find their own pecuniary interest subserved thereby, in securing a greater degree of public confidence in steamvessels, and a consequent increase of patronage, as well as in lessening the hazard attending this species of property, and affording them the benefit of a diminished rate of insurance.

The committee, therefore, report a bill embracing the foregoing provisions.

APPENDIX.

A.

Statement showing the amount of steam tonnage of the United States registered and enrolled, as returned by the several collectors on the 30th September, 1839.

DISTRICTS.		Registered tonnage. Tons and 95ths.	Enrolled tonnage. Tons and 95ths.
Waldoboro',	Maine	–	67.53
Bath,	"	–	575.14
Boston,	Massachusetts	–	2,243.10
New Bedford,	"	–	57.01
Nantucket,	"	–	171.20
Providence,	Rhode Island	–	487.00
Newport,	"	–	211.11
Middletown,	Connecticut	–	796.29
New London,	"	–	346.45
New Haven,	"	–	784.10
Fairfield,	"	–	291.70
Vermont,	Vermont	–	1,364.42
Sackett's Harbor,	New York	–	896.80
Oswego,	"	–	629.20
Genesee,	"	–	139.00
Oswegatchie,	"	–	508.62
Buffalo Creek,	"	–	4,916.00
Sag Harbor,	"	–	29.87
New York,	"	–	30,348.57
Perth Amboy,	New Jersey,	–	498.47
Newark,	"	–	291.55
Camden,	"	–	1,136.57
Philadelphia,	Pennsylvania	–	8,424.55
Pittsburg,	"	–	11,864.71
Wilmington,	Delaware	–	373.60
Baltimore,	Maryland	360.31	7,754.83
Annapolis,	"	–	336.42
Georgetown,	Columbia	–	1,123.35
Alexandria,	"	–	984.16
Norfolk,	Virginia	–	1,209.85
Richmond,	"	–	147.70
Wheeling,	"	–	2,268.74
Charleston,	South Carolina	74	2,984.05
Savannah,	Georgia	2,217.87	4,294.91
Brunswick,	"	–	408.03
Miami,	Ohio	–	1,801.30
Cuyahoga,	"	–	3,917.46
Sandusky,	"	–	2,272.67
Cincinnati,	"	–	9,159.47
Detroit,	Michigan	–	3,160.17
Mobile,	Alabama	236.54	3,714.06
Louisville,	Kentucky	–	8,125.87
St. Louis,	Missouri	–	9,735.00
Nashville,	Tennessee	–	4,240.94
New Orleans,	Louisiana	2,314.93	61,213.67
Appalachicola,	Florida	–	1,559.67
Total		5,203.75	194,365.94

Recapitulation of the steam tonnage of the United States.

	Tons—95ths.
Employed on the Eastern waters	54,473.59
Employed on the lakes	18,341.27
Employed on the Western waters (rivers)	108,923.58
Employed south of the Potomac river	17,831.15
	199,569.64

B.

LOSS OF THE LEXINGTON.

Testimony of the pilot, Captain Manchester.

The following testimony of Captain Manchester, the pilot, and who is one of the four that were saved from the Lexington, was taken before the coroner of New York:

Captain Stephen Manchester, being sworn, deposed as follows:

I live at Providence, R. I. I follow the water for a livelihood, and have done so for about twenty years, as master, mate, and pilot. I have been pilot of a steamboat for five years. I was first pilot of the Boston two years, and then for three years past have been pilot of the Lexington, excepting about two weeks last fall; I was on board of the Narraganset while the Lexington was under repair. I piloted the Lexington through all the month of December last, and in January, until she was lost.

I considered the Lexington as good a boat as any on the line, and as good as any other, as far as I knew.

I have been in the employ of the New Jersey Company since March last.

Her steering apparatus consisted of iron-rods running fore and aft, excepting at the wheel; there was sufficient length of hide rope to go round the wheel, and at the stern a rope connected the rods with the rudder. I never saw a boat steered wholly with rods and chains.

I never knew the Lexington to be on fire before. I have been told, since this investigation commenced, that she was once before on fire on coming into the dock here. I have nothing to do with loading the boat. My sole business is, when the boat is ready to start, to go into the wheel-house and there remain until she arrives at her place of destination. I have stowed freight and cargo on board of sloops, but not on board of steamboats. I have never taken observation of the manner of stowing steamboats' freight.

The freight of the Lexington, on her last trip, consisted chiefly of cotton. She had a small quantity of other freight. The mate (Mr. Thurber) told me she had on board about one hundred and fifty bales of cotton; I did notice the manner in which the cotton on board was stowed; it was done in about the usual manner, some bales on the side and some on the end; there were some bales on the boiler hatch; we had but little wood on board; what we had was stowed in small rooms each side of the engine; these rooms could hold some five or six cords of wood; during her last trip, but one, there were carpenters on board at work—I think making a baggage-room—but before her starting on the last trip, some workmen were on board repairing the furnace-blowers; these workmen did not go on the trip; I am not an engineer, and am not competent to judge of the boat's machinery; the freight was so stowed as to admit of a free passage, fore and aft, for those on board, and no one could be incommoded thereby; I never knew it otherwise; I was in the wheel-house, at the wheel, when the alarm was first given; it was about half-past seven o'clock in the evening; I was first notified of the danger by some one who came to the wheel-house door and told me that the boat was on fire—don't know who that person was; my first movement was to step out of the wheel-house and look aft; I saw the upper deck on fire all around the smoke-pipe, and blazing up two or three feet, perhaps, above the promenade deck; the flame seemed to be a

thin sheet, and, apparently, but just commenced; the blaze seemed to follow up the smoke-pipe, and was all around it; I again went into the wheel-house, caught hold of the wheel, hove it hard aport, and steered the boat head to land; I thought, from my first view of the fire, that it was a doubtful case whether it could be extinguished; we were, when the fire broke out, about fifty miles from here, off Eaton's neck, and some *four* miles from the Long Island shore; at the rate the boat was running, she might probably have reached the shore, if rightly headed, in twenty minutes; it took some three or four minutes to get her head about; we were steering about east by north; the nearest land was south from us; we had not got the boat headed round before the tiller-rope gave way; she was heading about southeast, and the land we were desirous of reaching lay about south when I lost command of her from the giving way of the tiller-ropes; the engine was at this time working; I don't know where the engineer was at this time; the boat, as she progressed, headed more to the eastward; as I had got the wheel hove over hard aport, Captain Childs came into the wheel-house; as he came into the wheel-house, he put his hand on a spoke of the wheel, and at that moment the rope gave way.

The larboard rope was the one which gave way. I presume it was the rope attached to the wheel which gave way, but I don't know positively. At this moment the smoke came into the wheel-house so violently that we were obliged to leave it. I don't recollect having seen Captain Childs afterward. Captain Childs did not make any remark relative to the boat.

As I stepped out of the wheel-house, I called to those on the forecastle to get out the fire-engine and buckets. The engine they succeeded in getting out, but I did not see any of the buckets, except two or three which we found afterward on the forecastle. I believe that the ropes were not parted by the strain, but were burnt off; I could not, however, have remained longer, for the smoke, had there been chains on the wheel. I think there was at this time a sufficient chance for a person to go aft upon the promenade deck. The boat had a good tiller, rigged with chains; I know that this apparatus was in good order. All boats are rigged in this way, to provide against accident to the wheel apparatus. I should have gone aft to the tiller, but I thought that, if it could be used, there were enough persons aft to do so; besides, I thought my services were more needed forward. After calling for the fire-engine, I went to the life-boat, where I found some persons stripping off her tarpauling covering. I don't know who any of these persons were.

I did not know Captain Hilliard, nor should I now know him. I requested that the boat might not be let go over the side till we got a line fast to her. A line was passed and made fast to the bows of the boat; the line was taken forward, and I ordered it to be made fast to the steamboat, to keep the life-boat from going off when thrown into the water. The fire was then burning through the upper deck, around the life-boat. I cut the lashings, and she was launched; I jumped down upon the forecastle and caught hold of the hawser myself; I found that the hawser was not made fast to the steamboat, forward. Several persons took hold of the hawser, enough to have held fast and saved the boat, but they let go, one after the other, until I was obliged to let go myself. These persons who were with me, and had hold of the hawser, were some of the deck-hands and waiters; there were one or two passengers and the wheelsmen. The boat having been lost, we then caught hold of the two buckets, and with them and some

specie boxes, which we broke open, we commenced throwing water upon the fire. We threw the water from over the boat's side. The engine was then pretty much stopped. While some were throwing water, myself and others took the flagstaff and another spar, and, knocking off some of the bulwarks, we lashed them to the spars to make a raft, in hopes that we might thereby save some of us. We made a line fast to it, and launched it over the side. There were on the forecastle four baggage-cars; these we emptied of the baggage, which we threw overboard, and, making fast a line to the cars, we threw them over the side also. The engine had now entirely ceased working. I think it worked some fifteen minutes after the fire broke out. It did not stop suddenly, but kept working slower until stopped entirely. Having secured every thing that we thought a person could save himself on, we continued to throw the water. As the fire approached us, we still kept the water going, until the main deck had fallen in as far forward as the capstan, in hopes that some one might come to our relief. People, by this time, had been getting over the sides, and were hanging on the baggage cars and things, and some were already drowned. The fire had now extended completely under us, and was bursting out of the forescuttle "right in the eyes of her." We were now cornered up into so small a space that we could do nothing more with the water; what few there were left with me, some eight or ten in number, now asked me what they should do. I said, I see no choice for any of us; if we remain here, we must inevitably be burnt to death; and, if we go overboard, we shall, with equal certainty, perish. Among those who remained to the last was a Mr. Van Cott, Mr. Hoyt, and Mr. Harnden, of the Express; these were all the passengers whose names I can recollect.

I took a piece of spun-yarn, tied it round my coat, made it fast to the rail, and with it eased myself down upon the stage or raft. As I stepped on to it, it sank from under me partly. I raised myself up by the line till it rose again; I then sprung and caught hold of a piece of the boat's railing, which had burnt and fallen off. From that I got on to a bale of cotton, on which there was already another man seated. Finding that the bale was made fast to the piece of railing, I cut it loose. About the time when I cut it loose, some one who was standing upon the piece of rail, asked me if there was room for another on the bale. I made him no answer. As he spoke, he jumped and knocked my companion off the bale. He fell into the water, and regained his position upon the piece of railing, and I hauled my companion again upon the bale. I caught hold of a piece of board, which was drifting past, and with it shoved the bale clear of the wreck, and let it drift down the sound. I tried, with the piece of board, to make in for the land, in order that I might fetch inside of Crone neck, and not drift past it. I did not succeed in this, but continued to use the piece of board, for exercise, as long as I could use it. When I left the wreck I looked at my watch, and saw that it was just twelve o'clock. The man, who was on the bale with me, told me his name was McKinney, and that he lived in New York. He appeared much exhausted when he first got on the bale; he was giving up entirely, when I told him to thrash his hands, which he did for a time. About daylight, he fell back upon the bale of cotton, and the first sea that came he fell off, and went down without a struggle. My hands had not become so frozen that I could not use them at all. I looked at my watch at one o'clock, and again at two, but could not afterward get at it. I think that the wreck sunk at about three o'clock. I think I was

distant from the wreck, when it sunk, about three miles. A short time after sunrise I recollect seeing a sloop to the windward. I managed to put a handkerchief upon the piece of board, and raised it up, holding it between my hands. My fingers were now so frozen that I could not bend them. At first I set astride of the cotton bale, but, getting the cramp in my legs, I drew them both on one side, and sat crosswise of the bale. I did not get knocked off the bale at all, though there was, at times, a heavy sea on. McKinney spoke to me of his wife and children, whom, he said, he had kissed on leaving them that morning. He said that he had never been through the sound before.

I was picked up by the sloop Merchant, Captain Meeker, who treated me with the greatest kindness. I was taken to the house of Captain Godfrey, at Southport, where I had every comfort and attention that could be afforded or desired.

I have known Captain Childs some ten or fifteen years. We were packet-masters together for several years, since when we have been in steamboats. He has always been in this line of boats. He was a very steady, smart, and capable man for the business in which he has been engaged.

When he came to me in the wheel-house, he appeared somewhat agitated, though I could not, from the short time he was there, take particular notice. There did not appear to be much confusion among those forward—how it was aft, I do not know.

In my opinion, the fire originated from the heat of the smoke-pipe, which was communicated to the woodwork. I have frequently seen the smoke-pipe red hot, and saw it so on the last night. I do not know whether the red heat ever extended to the flange or not. The cotton was piled within, perhaps, a foot of the steam-chimney—it might have been two feet. The flame which I first saw appeared to be that created by the burning of wood, not of coal. The tiller aft was always shipped and in order for use. I think that, in consequence of the smoke which fell aft, that a man could not have continued at the tiller until the time when the engine stopped.

I think a boat could be steered through Hellgate by tiller-chains, though there would be more danger than from the use of ropes, as, in cold weather, the chains would be more likely to break. I think that the ropes used on board of the Lexington were as safe as any chains that could be rigged. I do not think, had chains been used on board of the Lexington, that I should have been more likely to have reached the shore with her. I never had any apprehension of the Lexington taking fire, nor did I consider her any more likely to take fire than any other boat.

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Testimony of Captain Chester Hilliard.

I am a native of Norwich, Connecticut, and have followed the sea for the last six years. I am 24 years old.

A week ago last Monday I went on board the Lexington to go to Norwich. Embarked about 3, P. M., on the route to Stonington. Did not know the number of passengers; should judge there might be 150 from what I saw at the table, but since have been inclined to believe that a very high esti-

mate. Paid no attention to the stowage of the cargo; the principal part appeared to be cotton, and it was stowed under the promenade deck. There appeared to be room for one man to go between the paddle-wheel-house and the companion-way. Think there was one tier of cotton bales stowed in that space. I was forward on the forecastle, and saw three baggage cars, which were pretty near all that were there. Saw the life boat just forward of the wheel-house, on the starboard side; she was covered over with a piece of canvass. I observed the quarter-boats, but did not pay any particular notice to them until they were lowered away from the davits. Took supper about six, P. M.; there were two tables, but they did not run the whole length of the cabin. There was a stove in the centre; the tables were so full that some passengers had to wait. Saw nothing wrong in the management of the boat before supper. At that time she might be going at 12 to 14 knots an hour. Thinks it likely that the supper occupied from one-half to three-quarters of an hour. I cannot say if Captain Childs was there or not. Heard the cry of "fire" about one hour after supper. Was on the point of turning in, when I heard the alarm of fire. Threw my coat and boots off; my berth was in the after cabin, not far from the companion-way, on the starboard side. It was the third berth from the stairway. I did not apprehend anything serious, but went up on deck and took my overcoat on my arm. When I got on deck I observed the casing of the smoke-pipe on fire. What struck my attention most was the general rush of the passengers for the boats. I think it likely that the promenade deck was on fire also at that time; I think it was below the promenade deck, but not below the main deck.

It was the first time I was on board the boat; and I do not know anything about her chimneys, one way or the other. I did not hear any orders from the commander; but from what I observed among the crew, forward, I should suppose they were rigging the fire-engine. I do not think that any buckets had been used when I first saw the fire. There were buckets on board, but I cannot say how many. I do not know the fact, but I think the engine was not got to work. I left the main deck and went on the promenade deck. Soon after I got up, I thought the people on board seemed to be stupidly determined to destroy themselves, and the boats also, their only means of safety. I repaired to the starboard boat, which they were lowering away. They got the boat partly over, until she took the water, and then some one cut the forward tackle, when she filled and went astern. I think about twenty persons were in her then. The other boat was lowered, and went down in pretty much the same way; she was also full of passengers. I cannot say that she was cut loose, but I think the tackle ran through the blocks; I cannot say if there was any painter; if there was, it must have parted. At that time, the fire had got agoing so, that I had made up my mind "it was a case." I thought, then, that the only method to save our lives was to run the boat ashore; and, for that purpose, I went to the wheel-house to consult with the captain. Saw him, and told him the best thing he could do was to run the boat ashore. He said the boat was already heading to the land. The fire, at this time, began to come up above the upper deck, and the wheel house was filled with smoke. Some two or three persons were in the wheel-house and on the promenade deck, and their attention was turned to the life-boat. I told them they must be quick or she would be burnt. I lent a hand to clear off the tarpauling, but did not make up my mind to get in her, as I thought she

would be filled. I thought the chance was that she would go the same way as the others. What became of her I do not know, for the fire gained so much that I was obliged to go away from that part. I then went aft to the main deck, and they were at work with the hose. I think it was screwed on to the force-pump. The smoke was so dense that I could hardly see what they were about; and I think that, at that time, the communication was cut off fore and aft. From the time of the first alarm to the time I am speaking of, it may have been fifteen or twenty minutes; and about that time the engine stopped. I suggested to the hands to throw the cotton overboard, which they did, and I helped to get it out. I said we had to do something, and that too pretty soon. The best refuge, in my opinion, I said, was the cotton. We got out all that was not on fire on the larboard side of the boat; there were ten or twelve bales put over, and I cut off four or five fathoms of line, and attached it to the last bale that was not on fire; it was a flat square bale of the ordinary size. I put the rope round the middle, and took a round turn with the rope after we had it on the rail, and then slipped it off, and got on it ourselves, below the guard, by means of the rope; we then lowered ourselves and the bale into the water. The boat at this time lay head to the shore, with the wind on her broadside; we were on the larboard side of the boat, under her lee; this was ten minutes after the engine stopped. We sat on the bale of cotton, facing each other, and it floated about one-third out of the water; the wind was pretty fresh, and the boat drifting about a knot and a half. We looked out for something to steer her with; but first we wound up the ropes by which we had lowered the bale from the wreck. My companion opposed leaving the wreck, but I was determined not to stay and be burnt, and we shoved the bale around the stern of the steamer. The boat then drifted from us, and perhaps we got a knot and a half from her. That was at 8 P. M., because I noted the time. I got then a piece of board that would enable me to keep the cotton to the windward. At this time, I should suppose, nearly everybody had left the boat, for the ladies' cabin was all on fire; but I saw one lady and two or three other persons on board. The reason why I noticed this lady was because her child appeared to be floating on the water; we passed it quite close, so that I could have put my hand on it as it lay on its back; the mother saw us and sung out for us to save it. We then drifted away, and could see no one except a fireman on the forecastle. Should have judged the child to have been a girl from its dress. It was quite dead, and we did not attempt to get at it. Cannot describe the lady, or recollect the words she said. The fact is, I had my hands full to take care of the bale of cotton. My feet, of course, were in the water, and I was wet up to the middle. We kept in sight of the boat until she sunk, which was at 3, A. M. I should say we were above a mile off her at that time. At the time we left the boat it was cloudy, but it cleared off, and the moon shone out, and we had a fine night. I noted the time about every half hour. It was not so intensely cold, but it required great exertions to keep the blood in circulation. I beat my hands together, and took other means for that object. About 4, A. M., the bale capsized, in consequence of a heavy swell; it went right over endwise, but we both managed to get up on it again, and then we had lost the piece of board, and the bale became ungovernable. My companion complained of the cold from the first setting out, and did not seem to have that spirit about him that he ought to have had. He kept troubling himself about things he had no business to mind at that time. His name was

Cox, and his wife lived at No. 71 Cherry street. After the capsize he did not seem to have much hope. He was thinly clad, and I gave him my vest; he had only a flannel shirt and trowsers, boots, and a cap; he was one of the firemen on board the Lexington. I think he fell off about two hours after the bale had upset; for the last half hour Cox had been stupid, and had lost all use of his hands, and he could not hold on to the bale. I did what I could to keep his blood in circulation, but without effect. The sea continued very rough, and I was obliged to have hold of the rope to keep on myself; the bale was broadside to the sea, and I had much ado to keep it steady. At last he slipped off and sunk without a struggle. I got then more on to the head of the bale, to make it more steady, and I continued there until picked up. For the last hour it was so smooth that I got on the bale altogether and sat down. I consider it was about half-past six, A. M., when the man fell off. When I saw the sloop I waved my hat to excite their attention, and they bore down and picked me up. She was the Merchant, from Southport, Captain Meeker; he asked me if I knew of any others, and made other inquiries of me, as he had come out on purpose to see if he could render any assistance. They are entitled to great credit; for I know of no other persons who have done so, except the steamer Statesman. Captain M. had to take out part of his cargo, in order to get the sloop over the bar. It was morning before he could accomplish this. It was about 11, A. M., when I was picked up, as the sloop had to beat down to windward. The sloop had been in to speak the light-boat off Eaton's Neck, and to ask her crew if they could point out whereabouts the fire occurred. The captain of the sloop paid me every attention, and then went to cruise after any other sufferers. They picked up two men alive, and two dead bodies. One was Manchester, the pilot. I think he was on a bale of cotton. The other was Charles Smith; he was on the wheel-house. The pilot was picked up first, while I was below. I should say they were both found within half an hour after I was on board the sloop. The pilot was pretty much gone, and I thought the other seemed better. They put them both to bed. Smith was a fireman on board the Lexington.

Coroner. How did Captain Childs appear when at the wheel-house?

Witness. Why, he was confused.

Coroner. What did he say?

Witness. He said nothing that I heard, but that he was running for the land.

By the jury. That was the last time I saw him, and I am inclined to think he was suffocated at the wheel, from the fact of his not being seen afterward. With regard to the tiller-ropes, I am of opinion they burnt off; but I know nothing positive about it, or how I acquired that opinion; I had no conversation with the man that was on the bale of cotton respecting the origin of the fire. I did not examine the place where the fire broke out, but I saw the fire when the quarter-boats were lowered away; did not see any of the other officers of the deck except the captain. I think that a man could have got aft after the life-boat was cut away.

I went aft of the gangway, but did not see any of the men or officers of the deck attempting to ship the tiller. I cannot say if it was shipped or not; in fact, I don't know anything about it. I do not know how near the cotton was to the wheel-house. The engine may have worked five minutes after the pilot left the wheel, if it was him that left, and got out the

life-boat. I had a talk with Captain Vanderbilt, and I may have said that when I first saw the fire, two or three buckets of water would have put it out. I should not like, perhaps, to say so little; but I do think that it might have been got under with but a little trouble. I should say that the quarter boats could not have been lowered under the direction of the officer of the deck.

Juror. What was the conduct of the officers of the deck respecting the lowering of the boats?

Witness. I did not see them do anything, but I know the engine should have been stopped before the boats were lowered away. Had the engine been stopped, and the buckets used, I think the fire could have been got out.

Juror. As the commanding officer of a vessel, should not you have deemed it your duty to save the boats?

Witness. Why, a man cannot be here and there, and everywhere, at such a time. Perhaps his first duty was to have put out the fire.

Juror. Do you think that, if Captain Childs had acted as a prudent officer, he could not have kept the boats at the davits?

Witness. I think it would have been very difficult to have controlled the passengers. The quarter-deck boats might have carried fifteen persons each.

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Testimony of John Clark.

John Clark examined.—I was a machinist, but I am now an inspector of steamboats, under the act of Congress; I reside at 83 Essex street; I was acquainted with the steamboat Lexington, and inspected her the 1st of October last; she was all correct, and we gave a certificate. The whole top of the boiler was removed down to the flue last fall. The bottom was also repaired; I do not believe the steering department of the boat belongs to our duty; we do not examine the steering gear; we have nothing to do with that, only the engine and boiler; I did examine the steering apparatus—it was two rods under the promenade deck, with hide ropes round the wheel. These ropes were within ten feet fore and aft of the stern post and the tiller wheel. [Here the coroner read the law to the witness, but the latter persisted that he had nothing to do with the steering apparatus.]

By the jury.—I only consider myself bound to inspect the hull, boiler, and machinery; I go first on deck, then below, and look about, when I inspect a vessel—nothing more than look at the wood and iron.

Coroner.—Have you ever condemned a boat?

Witness.—We never condemned any boat. We have restricted them to a certain amount of steam.

Juror.—Well, when you inspect a boat you look at the wood, and do nothing else?

Witness.—Yes, we take our fees.

Coroner.—What boats have you ever restricted to a certain amount of steam?

Witness.—Why, some of the ferry-boats on the North river. A year ago last fall, we restricted the Rhode Island, because the boiler was rather weak. We have also restricted the William Young, and the Superior.

Juror.—Was the restriction complied with?

Witness.—I suppose so.

Coroner.—Did you ever restrict the Nimrod?

Witness.—Yes; because she wanted a new boiler.

Juror.—Was any restriction ever put on the Lexington?

Witness.—No, sir.

Juror.—How do you examine the hull of a vessel?

Witness.—Why, I examine it.

Juror.—How?

Witness.—With my eyes.

Juror.—Do you mean to say that you see every vessel that is hauled out of the water?

Witness.—Yes.

Juror.—Well, we want to know your mode of proceeding.

Witness.—Well, I go and inquire the boat's age.—How much do you suppose I am to do for five dollars?

Juror.—No matter, sir, about the fee; we want to know your mode of proceeding.

Witness.—Why, I examine the hull, and I look at the engine; I have worked at and made almost every kind of engine for the last thirty years.

Juror.—Mr. Coroner, am I in order in asking this question: how he found the hull of the steamer William Young?

Coroner.—Yes, sir.

Witness.—Well I think he is not, sir.

Juror.—Oh, I have several other boats to question him on, sir.

Witness.—Well, sir, this juror may be a steamboat owner, and may wish to get up a prejudice against a particular boat.

Coroner.—About the William Young, sir?

Witness.—Why we gave her a certificate that she was of such an age, and was suitable to run the river with a certain amount of steam. The boiler was an old one. We gave her a certificate last October.

Juror.—Have you examined the Providence, of Newburg?

Witness.—Not this year.

Juror.—Why, then, do you allow her to run?

Witness.—Why, it is the duty of the master to apply, or run the risk of being informed against.

[Here, the coroner stated he had some doubts about the propriety of x - amining the witness as to particular steamboats, except as they referred to the case of the Lexington.]

Juror.—In due deference to your better judgment, sir, I think he is bound to say how he proceeds in the examining of steamboats. It is the opinion of the jury, that the inspectors have passed steamboats as safe, and given them certificates when they were not worthy of it. If we are traveling out of the road, why, we submit to your correction.

Coroner.—I do not think this man is on his trial; and all that we have to do, is to inquire about the Lexington.

Juror.—Why, sir, suppose it could be proved that he has examined and passed boats unworthy of it, would it not be a fair presumption that he may have done the same in the case of the Lexington?

[The answer of the coroner escaped the reporter.]

Question.—Are you interested in the Lexington?

Answer.—I have not a cent invested in any steamboat whatever. I think the Lexington was not so well calculated to carry freight as passengers, although she was strong enough to carry any thing. We gave the William Young a different certificate to that given to the Lexington.

Juror.—Do you think you have a right to give such a certificate?

Coroner.—I don't think he is bound to answer.

Witness.—Why, if you pump me in that way, you will get out the secrets of every body's boat.

Juror.—How many bales of cotton could the Lexington carry?

Witness.—I did not think she could carry one with safety; as it regards safety from *fire* I mean.

Testimony of Richard M. Hoe, one of the jurors.

I live at 309 East Broadway; am of the firm of R. Hoe & Co., machine-makers, &c.; I never was on board the Lexington; but have been in most of the other boats on the sound, and taken notice of their machinery; I have also visited Europe, and seen their machinery in operation there. The working parts of ours compare very well; they are as well adapted, though not possessing quite so much weight of metal, or so much finish, but it is better proportioned to do its duty; the reason for that is, that here, we are obliged to make a little iron go a great ways. Our engineers will take the same weight of metal, and make a stronger engine; with regard to a protection against fire, there are more precautions taken in the very poorest of the boats I saw in Europe, than there are in the very best boats I ever saw in the United States. The bituminous coal is generally used. They generally have but one steering-place, which is aft: they have a tiller rigged like a packet-ship, and keep a look out forward; I believe that if a proper chain were used, it would answer as well, or better, than rope, especially if made of the best metal; I think it would act with more certainty, and with more convenience. I think in going through Hellgate, a chain might be rigged so as to work as well as rope; I made up this opinion from what I have seen of the mechanical operation of chains; frost affects iron, and might destroy a chain here quicker than in England, but it would not have a greater effect on a chain than it would on an iron-rod. I have always thought that our steamers were badly protected against fire; the European steamers have cast iron plates for the floors, and the rooms are lined with metal throughout; in many of them, the fireroom is a complete box of iron; I have also seen wire tiller ropes, they appear to answer very well; it is a recent invention, but we have it here; the standing rigging of the Liverpool is made of that material; I have heard that the North river boats have wire tiller-ropes. I was on board of a steamer in Europe that caught fire in the forward cabin; they had a force-pump or two on board, but no fire engine; it was a smothered fire and they had to cut away the deck before they could get to it; when that was done, the hose was carried to the spot, having a cock to it, by which means, we had the command of the water, and could carry it where we pleased, without calling to the men at the pump, through which the hose was supplied; it was, perhaps, three quarters of an hour before the fire was got at, but the captain was a pretty resolute fellow, and knocked down two or three that would not mind his orders; when found, it was inundated in a minute; it had covered a space of three feet square in the cabin ceiling.

Presentment of coroner's jury.

From the testimony adduced before the court of inquiry, by the coroner's inquest, to investigate the causes which led to the destruction by fire of the steamboat Lexington, the inquest are of opinion that the fire was communicated to the promenade deck by the intense heat of the smoke-pipe, or some sparks from the space between the smoke-pipe and steam-chamber; as the fire was first seen near the casing of the steam-chimney above the promenade deck. They are further of opinion that the Lexington was a first-rate boat, with an excellent steam-engine, and a boiler suitable for burning wood, but not coal, with the blowers attached. Furthermore, it is our opinion, that had the buckets been manned at the commencement of the fire, it would have been immediately extinguished. Also, inasmuch as the engine could not be stopped from the rapid progress of the fire, with presence of mind of the officer, and a strict discipline of the crew, the boats could have been launched, and a large portion of the passengers and crew, if not the whole, might have been saved.

It is the opinion of this jury that the present inspectors of steamboats, either from ignorance or neglect, have suffered the steamboat Lexington to navigate the sound at the imminent risk of the lives and property of the passengers, giving a certificate stating a full compliance with the laws of the United States, while, in our opinion, such was not the case. That the system, as adopted on board the Lexington, of using blowers on board of boats, is dangerous, which has been proved to this jury by competent witnesses; and that the conduct of the officers of the steamboat Lexington on the night of the 13th of January, while said steamboat was on fire, deserves the severest censure of this community. From the facts proved before this jury, that the captain and pilot, in the greatest hour of danger, left the steamboat to her own guidance, and sought their own safety, regardless of the fate of the passengers, instead of the captain or pilot retreating to the tiller, aft, when driven from the wheel-house, forward, and the ropes there being burnt off, there being at that time a communication to the said tiller, there appeared to be no other thought but self-preservation. And it further appears to this jury, that the odious practice of carrying cotton in any quantities on board of passenger-boats, in a manner in which it shall be liable to take fire from sparks or heat from any smoke-pipe or other means, deserves the public censure.

[Signed by—James Goadby, Thomas E. Burlaw, S. H. Herriott, Tennis Fokkes, James Green, P. M. P. Durando, jr., Edmund R. McVeagh, A. S. Chace, Abraham Crevelin, Robert Buttle, Richard M. Hoe, Henry V. Davis.]

We, composing part of the jury in the case of the loss of the Lexington, fully exonerate and exculpate Captain Stephen Manchester from any blame or censure after the breaking out of the fire on board.

[Signed—Benjamin Vincent, foreman; Joseph E. Mount.]

C.

Accident on board the Narraganset.

This occurred in August last, in Long Island sound. Several persons were scalded, more or less; none fatally. The following is a certificate of Captain Bunker, a steamboat inspector, at New York:

"On examination of the machinery of the Narraganset this morning, I found, from the account I received from the engineer of the boat (a very competent person), that the injective pipe, for the introduction of cold water into the condenser, had been obstructed, from an accumulation of seaweed or some similar cause (a common occurrence in the navigation of the sound); in consequence of which the condenser ceasing to condense, became violently heated; upon discharging which, the engineer then very properly opened the additional injective pipe to restore the usual action of the engine. In all probability, during this interval, two full discharges of steam had passed from the cylinder into the condenser; and when the second injective pipe was opened, the draught created thereby into the condenser, caused an immediate rush of the water, thus excessively heated, into the reservoir, in such volume as to produce its immediate overflow, with a force to precipitate it through the door, and to scald the unfortunate passengers who were in its vicinity.

"In this unpleasant occurrence, I can attribute no defect to the machinery of the Narragansett, and no want of skill or good conduct to the engineer. He pursued the same course which my own experience would have prompted me to do in like circumstances. I should have never apprehended injury from such a cause, having often known a like occurrence without any serious consequence or even cause of alarm.

"ELIHU J. BUNKER.

"NEW YORK, *August* 14, 1839."

D.

FRANCIS'S LIFE-BOATS.

Communication from Mr. Joseph Francis, of New York.

These boats are of the improvement of Joseph Francis, of New York. An enlarged description is not here necessary, as the principle of their construction is very generally known throughout the Union. It may be well, however, to say, that the difference between these and all other former life-boats is, that in Francis's boats the sustaining power is placed in the *bottom* of the boats, in order to keep the frame high out of the water, in case a hole should be stove in the boat by a rock, shot, or other cause. The model or form of the boat's bottom differs from all others ever before constructed, the bilges being much lower than the kelson (see sketch).

In the bilges of the boat are placed copper cylinders or chambers, air-tight, the whole covered with a strong flooring, which leaves as much inside room as in boats of ordinary construction. They are as light and as easy to manage as boats in common use—are fast sailers, and cannot possibly be swamped, under any circumstances, by any number of persons who may crowd into them, or hang around by the life-ropes.

To prevent a life-boat being lost or cut loose when half loaded with passengers, a strong chain should be attached to the bows by one end, and the other secured to the stern of the vessel so that those who get into the boat first would not have it in their power to cut loose until she is loaded.

A *common* quarter-boat, 25 feet long, will carry, in a smooth sea, 35 persons; a life-boat, of same length, 75 persons—cost of the former, $125; cost of the latter, $250.

A Francis life-boat, suitable for lakes or seas, 25 feet long, 6 feet beam, and 3 feet in depth, will carry inside 75 persons, and will sustain as many more outside as can hold on to the life-ropes attached to the gunwale. The price of such a boat is $225. They are strong, substantial, and fit for the common uses of steamvessels, and of a safe model for storms and heavy seas. Boats of less dimensions are afforded at proportionally less prices.

Flat bottom life-boats, which will answer for rivers and other smooth waters, where sea-boats are not necessary, can be made to carry 400 persons, at a cost of $230; smaller boats in proportion.

Francis's life-boats have been placed, by the order of the Secretary of the Treasury, on board of all the revenue cutters on the Atlantic coast; they are in several vessels of the United States navy, for which others are now building; in the vessels under control of the War Department; on board many of our packet-ships, merchant vessels, and steamboats, and in the Texas navy. Those on board the revenue-cutters have proved highly useful in the preservation of lives during the past year, as appears from documents signed by several commanders.

In 1839, the gold medal of the American Institute was awarded to Mr. Francis for his improvement in life boats; and the following report was made to the institute upon the subject:

The undersigned committee, appointed by the American Institute for testing the utility of Mr. Joseph Francis's life boat, by an experiment made on the Hudson river on the 14th September, beg leave respectfully to report:

That they proceeded, according to appointment, to Stryker's bay, on the banks of the Hudson, where they were met by Mr. Francis, who there presented for their inspection *three* boats, viz: The first was an ordinary or common ship's long boat, which was manned by three sailors, who, in a few moments, found themselves in a sinking condition; and finally the boat swamped, and they were compelled to seek safety in one of Francis's small life-boats, hard by, measuring only 8 feet long and 3 feet beam—computed power 320 pounds, which will sustain *twenty-one persons* in the water, if so many can hold on to her. While the three men were in this small life-boat, the committee directed them to swamp her, if possible; every effort was made to do so, without effect. The men were then transferred, together with one other man, making four persons, to Francis's large life-boat, built to order, for a United States revenue-cutter, measuring 20 feet long, 4 feet beam, with stationary trip cylinders; her power is computed to sustain 3,500 pounds iron, or dead weight, and 230 persons. Many experiments were tried at the suggestion of the committee. After placing the boat in a suitable position, regarding depth of water, &c., &c., an attempt was made to upset her by her crew of four persons, in which they failed. One other effort was directed to be made to upset her, which was successful; but, immediately on relinquishing their hold, she righted with a celerity of motion that proved, beyond a doubt, its great buoyant principles. Those experiments were several times repeated; and your committee have the satisfaction to say, that their hopes and expectations, with regard to this great improvement for the preservation of human life, were fully realized.

If this boat ship a sea, or otherwise fill, there are six openings in the bottom to let the water out, viz: Four scuttles, 13 inches by 5, and two brass screw boxes, opening two four-inch holes, which it is said will relieve her in two minutes. While the men are inside, and the apertures are open, allowing a full flow of water in and out of the boat, the oarsmen propel the boat with the same velocity as though she was tight.

Francis's life-boat was invented in 1816, and an improvement made by him in 1837, which improvement your committee perceive consists in adding to the number of sections of copper cylinders, charged, as they are, with hydrogen gas and atmospheric air, together with the construction of the cylinders adapted to the form of the boat; this, your committee look upon as a decided improvement, particularly for *naval purposes*, as, if by a shot, one or two sections on both sides of the boat are perforated, sufficient buoyancy will be left to sustain all that may be required for boarding, or any exigency, as there are eight sections on either side of the boat.

The first life-boat, of which your committee have any knowledge, was constructed by Mr. Greathead, in England, in 1790. She was 30 feet long, 10 feet beam, 3 feet 4 inches deep; her sides were cased with cork, 4 inches thick, 16 inches deep, and 21 feet in length. She had six thwarts; under each was cork, making in all 700 pounds of cork. The whole buoyant power of Greathead's boat was around the top, which, when upset, prevented her righting. Another objection to her was, that so soon as the cork became saturated with water, it lost all its buoyant quality; and, when thus saturated, was subject to rapid decay. Your committee consider Francis's life-boat has a decided advantage, in every point of view, over Greathead's, or any other within the knowledge of your committee.

Another improvement in Francis's life-boat was introduced after the loss of the steamboat Home, in 1836, which was, to run his copper cylinders, charged with hydrogen gas, through the inner surface of his boat to the gunwale. Previous to this time, his principal buoyant power was near the gunwale, which prevented her turning back when upset.

It would have been very desirable to your committee to have seen and experimented upon Francis's life-boat in a boisterous surge; but as the day designated for the committee to attend the exhibition was calm, and the water tranquil, we beg leave to introduce the testimonials of some of our experienced naval officers and packet masters, well known to your committee, and upon whose statements the most implicit confidence may be placed.

From Captain Gedney, of United States brig Washington.

"In the spring of 1838, I was directed, by the honorable Secretary of the Treasury, to have a life-boat built on your plan, and by you, and to test her capacity as a sea and surf boat. I did so the following summer, to my entire satisfaction, and pronounce her to be well adapted to live in any sea or surf. When going through the surf, a grapnel should be let go just outside the breakers, that the boat may tail in stern foremost; in this manner, you may land in the heaviest surf.

"In landing once on the outside of Long Island, in a very heavy surf, without the above precaution, she was run on the beach where there was no shelving, but right up and down; and, after reaching the shore, she was overturned (with ten persons in her); her two upper planks on the starboard side were stove, and both planks next the keel were ripped nearly

off. Nevertheless, in this condition, she was pulled through the surf to the brig (the Washington), then about two miles distant."

"Yours, &c.,

"THOMAS R. GEDNEY,

"*United States Navy.*"

From the Secretary of the Treasury.

Entertaining a favorable opinion of Francis's life boats, and believing them to be peculiarly adapted to the discharge of the duties assigned to the officers of the revenue-cutter establishment, I have concluded to authorize one for each of the cutters embraced in the enclosed list. [Here follow the names of all the cutters from Eastport to Savannah.]

LEVI WOODBURY,

Secretary of the Treasury.

Trial of a fourteen-oared life-launch, built for the packet ship "La Duchess d'Orleans."

The undersigned gives notice that the following experiment was made with a newly invented life-launch, built for him by Mr. Francis: The anchor of the packet-ship Charlemagne was let go from the bow, and sunk into a muddy bottom, when the buoy-rope was taken to the boat, and it was hoisted up under her bottom with much ease; the stock was then taken up, which brought the anchor close up to the bottom of the launch; she was then floated round with much facility, and was found to draw only two and three-quarters inches more with the anchor attached. The anchor weighs seventeen hundred pounds, which, together with the chain, cannot be estimated at less than twenty hundred pounds, besides the men.

The undersigned is of the opinion (as far as his experience goes) that there is a decided advantage in the new method over the old, in carrying out and weighing an anchor, independent of the safety to passengers and crew in cases of emergency; in fact, it is well known to seamen, the general insufficiency of the common long-boat for that service, or any other.

The life-long-boat is carried between the main and mizen masts, on a frame similar to the way the whale-ships carry their spare-boats, and is always ready for service.

The dimensions of the life-boat are 32 feet in length, 7½ feet in breadth, and 3½ in depth. Mr. Francis estimates that her copper cylinders contain 11,302 square inches of air, which will sustain 5,050 pounds; that she will support 300 persons, and will carry inside 200, with a hole *stove in her bottom.*

HENRY ROBINSON.

In a former part of this report, your committee were compelled to state the dead weight Francis's life-boat was calculated to sustain from computation. They now have the satisfaction of stating, from a subsequent experiment, and ocular demonstration, that the boats fully sustained the weight there put down, to wit: The largest boat, built to order for a United States revenue-cutter, measuring 20 feet long, and 4 wide, with stationary trip

cylinders, will sustain 3,500 pounds dead weight, or 230 persons, in and around her; and the small boat, before alluded to, 320 pounds.

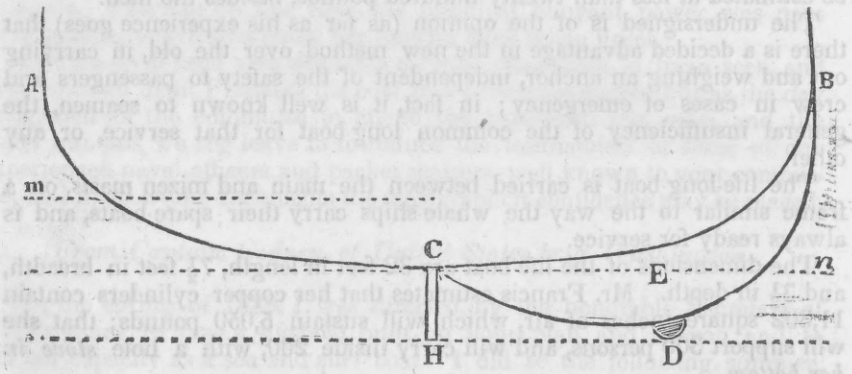
In conclusion, your committee recommend, for they consider the cause of humanity demands, that every packet, whose business it is to transport passengers, whether propelled by steam or canvass, should be provided with one or more of Francis's life-boats, the more certainly and effectually to preserve human life, in case of shipwreck or other accident.

All of which is respectfully submitted.

JOSEPH COWDIN, *Chairman, Merchant.*
ISAAC WEBB, *Ship Builder*
(firm of Webb & Allen).
F. W. MOORES, *United States Navy.*
JAMES HOSKEN, R. N.,
Com. Steamship Great Western.
H. L. SANDS, *Formerly of U. S. Army.*
JAMES ROGERS,
Past Com. Liverpool Packets.
C. WOODRUFF, *President of the*
Board of Improvements, Louisiana.
JOSEPH CURTIS, *Machinist.*
T. B. WAKEMAN, *Corresponding Secretary,*
American Institute.

The above report having been read and discussed, was unanimously adopted by the Managers of the American Institute, October 15, 1839.

Transverse section, showing on one side of the kelson the bend and bilge of a common boat; and, on the other, that of Francis's improved life-boat.



A. C. Bend and bilge of common boat.
B. D. C. Bend and bilge of life-boat.
E. Space occupied by air or gas in sections or chambers.
D. Oak bilge piece.
m. Water line of common boat.
n. Water line of life-boat.
H. Kelson.

Extract from a communication made by A. B. Quinby, of Baltimore.

"The danger from the heating of the chimney of the steam-boiler may be effectually prevented by adopting the plan used in the 'Philadelphia tow-boats.' The chimneys of the boilers of these boats are surrounded with a casing or cylinder made of boiler-iron, about four inches in diameter greater than that of the chimney, and extending upward (around the chimney) to a point above the highest deck of the boat. This surrounding cylinder is attached at the lower end and at the upper end, to the chimney of the boiler, and forms (between the outside surface of the chimney and the inside surface of the cylinder) a water *tank*. At the lowest point of this *tank* a water pipe is attached, which communicates with the interior of the boiler, at a point near the lowest part of the water reservoir. This communication is kept constantly open. At the highest point of the *tank*, the supply-pipe, from the pump, is attached; and all of the water which is supplied to the boiler, from the pump, is caused to pass through the *tank* which has been named; and, by this means, the temperature of the *tank*, and the chimney of the boiler to a point as high as the top of the tank, which is above the highest deck of the boat, are kept, always, during the time the engine is working, or the boat is running, nearly as low as that of the water, which is supplied to the boiler, at the point of its passing through the chamber of the pump. That the temperature of the water in the *tank* is always a little greater than that of the same water at the point of its passing through the pump is obvious, from the fact, that the interior surface of the *tank* is a *fire surface*, and of an extent amounting, perhaps, to sixty or seventy superficial feet: but this *fire surface* cannot, while the engine is working, or the pump is doing its duty, impart to the water in the *tank* a temperature so high as that of the water in the boiler; for, if the temperature of the water in the *tank* be supposed to be as great as that of the water in the boiler, then the *fire surface* of the *tank* must be sufficient to supply the full amount of steam required for the engine, and no other *fire surface* would be needed. This, we know, is not the case. Then, since the water in the *tank* is always at a lower heat than that of the water in the boiler, and as the temperature of the water in the boiler never exceeds about four hundred degrees of Fahrenheit's scale, we know that the *tank*, and the chimney to the height that the *tank* extends, can never have a temperature during the time the engine and pump are working, greater than four hundred degrees, which is far below the heat required to set wood on fire, or any similar fibrous substance. The adoption, therefore, of the plan for constructing the chimneys of steam-boilers, which is in operation in the 'Philadelphia tow-boats,' would *effectually* prevent the destruction of lives and property, from the cause which I have been contemplating. This means of preventing the burning of steamboats from the overheating of the chimney of the boiler is so extremely simple, and so entirely practicable, and could be adopted at so small an expense, that it has been surprising to me that more of the owners of steamboats, *from their own views of economy*, setting aside their duty to the public, have not put the plan into practical use. In many parts of our country, and most frequently in the southern and southwestern sections, steamboats have been destroyed by fire; and, in a large majority of the cases, many valuable lives have been lost; and, in the accounts which have been published in the newspapers of these calamities, it has been stated, in many instances, that

no one can tell from what cause, or in what manner the fire originated. The liability of the chimney of a steam-boiler, constructed in the manner of those of the Lexington, Wm. Gibbons, Pulaski, and New England, and most of those now in use in steamboats near our seaboard, to become heated to a *red* temperature, and to a height extending above the highest deck certainly leaves no room for doubt as to the cause which occasioned the burning of some of the boats in question. But there is another branch of this subject which it is my desire to examine.

"The effect of the *fire surface* of the *steam-chimney* in *surcharging* the steam—not only that portion of it which is contained in the *steam-chimney*, but, likewise that which occupies the chamber of the boiler, should receive the attention of every one who undertakes to investigate, fully, the causes of steam-boiler explosions.

"We have seen that the *fire surface* of the *steam-chimney* in either of the boilers of the late steamboat, New England, was equal to about sixty-seven and a half square feet; and the boiler of the Lexington being considerably larger than one of those of the New England, it may be assumed that the *fire surface* of the *steam-chimney* of the Lexington was equal to one hundred superficial feet. We may here bear it in mind, that it has been shown that the smoke or other matter, which passed through the *steam-chimney* of the Lexington, was at a temperature, at least, equal to that of *red-hot iron*. This fact it will be well to bear constantly in mind.

"To illustrate the facility with which highly heated iron (or other metal) imparts its heat to steam which is in contact with it, I shall quote a few cases in which the roofs of steam-boilers have become *red hot*, *during the time the engines were working*. The first cases I shall cite are from the able memoir on steam-boiler explosions, by M. Arago, of the Institute of France; and are translated and published in the Franklin Institute Journal, vol. 6, new series, page 58. The following are the words:

"'Mr. Moyle, in visiting his engines in Cornwall, found that one of the boilers had become so hot that a wooden scale [ladder] resting upon the top of the boiler had taken fire. A similar occurrence took place on board one of the packets between Liverpool and Dublin; a pine board, accidentally thrown upon the cover [top] of the boiler, took fire.'

"The first of these cases is mentioned by our countryman, Mr. Jacob Perkins, in his paper on steam-boiler explosions, published in the Franklin Institute Journal, new series, 1830. He received the account verbally from Mr. Moyle.

"In both of the cases which have been mentioned, the boilers were of the *low pressure* kind. *All* of the heat, therefore, which was received by the *tops* of the boilers, was conveyed by the steam from the flues, which were uncovered of water, and exposed to the direct heating effects of the fire. No other means exist, in case of a *low-pressure* boiler, by which the top or roof can receive heat, because there is always remaining a portion of water in the *leys*, which cuts off the conducting channel from the flues to the metal which forms the sides and tops of the boilers. From this, we are able to perceive that the steam, in both cases, was *red hot*, or at the same temperature.

"Another case is recorded which took place at Pittsburg, Pennsylvania, several years ago. A *high-pressure* boiler was observed to be at a *red*

heat on the top, on four successive days, and on the last day the boiler exploded.

"Professor Renwick, in his Treatise on the Steam-Engine, states, that the engineer of the late steamboat Etna, which was blown up on her passage from Amboy to New York, in 1825, had confessed that one of the boilers of that boat had been observed to be *red hot* on the top for half an hour before the explosion occurred. The boilers of the Etna were of the *high-pressure* kind.

"Mr. Parker, machine manufacturer of this city, informed me about eight yeas ago, that a *high pressure* boiler which had been used in their workshop, was observed to be at a red heat on the top for more than an hour, while the engine was working, and then an explosion took place.

"Mr. Dunham, of New York, of the firm of Browning & Dunham, stated to me, about a year ago, that one (or more) of the *high-pressure* boilers used in their establishment, was observed by him to be at a *red* temperature on the top for a considerable length of time, and no explosion ensued. The fire was reduced when the boiler was observed to be at the temperature named, and the engine was not stopped.

"A case differing from any other I have heard of, was mentioned to me a few months ago, by Mr. Hartshorne, of Philadelphia, which occurred under his care. The boiler was of the *high-pressure* kind. The pump being out of order, the water became too low in the boiler. This was known. The engine was still continued to be kept at work. The water was known to be falling (or believed to be falling) to a lower and lower level. After the engine had been kept at work, in this condition, for about half an hour or three quarters, the bottom of the boiler, at a point over the fire, gave way; and it was found that the boiler had become entirely exhausted of water. The opening in the boiler was examined, after the machine had sufficiently cooled, and was found to be of considerable size; almost large enough to receive a man's body. No explosion occurred. When the bottom gave way, there was a *puff* of steam upon the fire, but its violence did not produce any material damage. I do not remember that Mr. Hartshorne stated that the boiler was at a *red heat.*

"In all the cases which I have noticed, the engines were *working*, and some were of the *high* and some of the low-pressure kind.

"In one or more of the cases in which the low-pressure boiler was employed, no explosion occurred; and the same in the cases in which the high-pressure boiler was used. From the cases which have been cited, it is easy to perceive with what facility highly heated iron imparts its temperature to steam which is in contact with it; and we can safely conclude that the *fire surface* of a *steam-chimney*, which usually amounts to, at least, one hundred superficial feet, does communicate a very dangerous temperature to the steam in the *steam-chimney*, and, likewise, to all contained in the chamber of the boiler; and suppose the heat imparted by the *steam-chimney* to the steam in the boiler to be equal to five hundred or one thousand degrees of Fahrenheit's scale, the top portion of the boiler, that is, so much of the boiler as is above the water-line, will receive the same temperature; and then, if the water in the boiler, from any cause, should be elevated upon the highly heated metal, steam of a very dangerous tension would be formed; and in such quantity that an explosion would be likely immediately to take place. It has been supposed by some, that when a portion of the water in a steam-boiler is elevated into the steam when it is

in a *surcharged* state, the elasticity of the steam is suddenly increased, but this view is not entertained by those who are best acquainted with the subject of steam-boiler explosions. The *direct* experiment made on this point by the Franklin Institute, and recorded in the report of the committee on explosions of steam-boilers, 1836, gives no countenance to the opinion that the tension of *surcharged* steam in the boiler of a steam-engine, is increased by elevating a portion or jet of the water into it. The contrary opinion is satisfactorily established. There is another view which I desire to present, to show the dangerous effects of *steam-chimneys*.

"When a steamboat is lying at a wharf or landing, and the fire is raised to make steam for starting, the effect of the *fire surface* of the *steam-chimney* in *surcharging* the steam in the boiler, and heating the portion of the boiler which is above the water-line, is much greater than when the engine is in motion, or the boat is running. The reason is obvious. When the boat is lying at a landing and the engine is still, no steam escapes through the usual channel to the cylinder of the engine; and the whole volume of steam that is contained in the boiler is quiescent, and the heat from the *fire surface* of the *steam-chimney* is distributed with greater facility to the remote parts of the steam-chamber and the portion of the boiler above the water-line; and no heat escapes to subtract from the amount which the *steam-chimney* imparts; and the temperature of the portion of the boiler above the water-line is liable, in this case, to become intensely great. If, in this condition of the boiler, the engine is put into motion, or the boat is started, the water in the boiler being elevated against the highly heated metal by the motion of starting, steam will be formed of so high a degree of elasticity as to render an explosion likely to take place. And, granting that the boat does not leave the wharf, but merely, that the engine is put into motion, the foaming of the water, which it is known takes place at every stroke of a steam-engine, will cause steam to be formed on the highly heated portion of the boiler in such quantity, and having so high a tension as to endanger the lives of those who happen to be near the engine. It is true that, in many of the instances which fall under the example which has been stated, an explosion of the boiler does not take place; but, still, the steam is *surcharged* to a dangerous temperature, and the portion of the boiler which is above the water-line is heated to the same degree; and, though the peril which is impending does not fall, *the danger has been produced, and one more degree to the temperature of the boiler*, may occasion one of those calamities which it is the object of the steamboat law to prevent.

"If the view I have presented be correct, and, I have not a particle of doubt that the effect of *steam chimneys* is exactly as I have stated, the use of this form of steam-boilers cannot be too earnestly and strongly deprecated; and, I entertain the fullest conviction that the subject of prohibiting the use of *steam-chimneys* in boilers used in steamboats in our country, is among the most imperative duties which the present Congress is called on to discharge. The steamboat law should be amended so as to provide, that *no steam boiler, the flues of which stop short of the end of the boiler, and are turned up, and pass through the top of the boiler, shall be used in any steamboat, bearing a license from the United States.*"

Outline of legislative regulations recommended by the British commissioners, in their report on steamvessels, made to the board of trade, June, 1839.

1. That a board be appointed, in connexion with and under the president of the board of trade, whose business it shall be to register and classify all vessels navigated by steam, built, or building: the register to record detailed specifications of hull and machinery—periodical surveys to be made upon them—and particulars of all disasters and accidents which happen to, or may be occasioned by, steamvessels.

That the board be authorized to appoint local or district surveyors, to inspect and report upon the condition of steamers; that, on such report being satisfactory, the board shall grant licenses to the owners of steamvessels to ply; that, if unsatisfactory, they shall withhold such license, as far as relates to the conveyance of passengers. Penalty for plying without license.

That the board be empowered to investigate, personally, or otherwise, the nature and causes of accidents; to examine witnesses on oath; and call for the production of papers.

That the board be required to make an annual report to Parliament of its proceedings; of the state and progress of the mercantile steammarine; and of the disasters which may have been sustained.

That the records be public, on the payment of a reasonable fee.

That the board be empowered to frame and issue general instructions for the guidance of the local or district surveyors; also to publish an abstract of the law and regulations, with authority to require such abstract to be placed in a conspicuous part of the vessel; under penalties on neglect.

2. That the surveyors of hull and machinery be paid for their surveys by the owners of the vessels, according to a fixed scale, as is the practice for Lloyd's Register; that they shall forward their reports to the board, which, in the event of the owner or owners objecting to the repairs required, in order to entitle the vessel to a passenger license, shall (if the objection regard the hull) call in one or two of the principal shipbuilders of the port or district, unconnected with the work of such repairs, to survey the vessel, in conjunction with the official surveyor, and report specially thereon.

Should the decision of the board be objected to, on the report of the surveyor (if the objection regard the machinery), it shall call in the aid of one or more engineers to survey and report in conjunction with such official surveyor.

Special surveys to be paid for by the owner or owners of the vessel, according to a fixed scale.

The first survey of the hull of a new vessel to be made during its construction, and a specification of it transmitted to the board, as is now done by the surveyors of Lloyd's to the committee.

A survey of the hull to be made during each of the first two years, and a survey every six months subsequently. All steamers to be docked, beached, or laid on the gridiron (as circumstances permit) and surveyed, after sustaining any injury by taking the ground, or otherwise, under penalty.

The first survey of the boilers, engines, and machinery to be made while they are being fixed in the vessel, and the requisite details of them to be reported to the board.

Boilers, engines, and machinery, to be surveyed every six months after the first year, and all serious accidents to be reported.

The surveyors to report on the fitness of a vessel, whether as a *sea-going*, or *river* steamer.

3. License to express whether it be granted for cargo only; for towing-vessels; for the conveyance of passengers; or for these purposes combined; also, whether the vessel be intended to ply as a river, or sea-going steamer.

License to ply with passengers to be granted, or withheld, as aforesaid; a duplicate of which, or certificate to the same effect, signed by the board, to be exhibited in the cabin or other conspicuous part of the vessel. All public advertisements of steamers to state whether licensed to carry passengers or not.

An annual charge for each license to be made on all steamvessels, varying according to a scale of size and capacity; such charge to be in no case less than £1, nor exceeding £5.

4. That the surveyor shall ascertain that the safety-valves be sufficient to pass all the steam which the boilers can generate in their ordinary state of work, at the pressure determined by the weight on the valves; the maximum of which pressure shall be fixed by the maker of the engines, or boilers, and the valves be loaded accordingly.

5. That, after an assigned period, no passenger license be granted to any vessel having safety-valves, whose spindles or levers are exposed on deck, or capable of being loaded externally, unless satisfactorily protected. Penalty on engineers, masters, or others, for loading valves beyond the weight ascertained by the surveyor, and regulated as above.

6. That, in all new steamers, and, after an assigned period, in all steamers now afloat, glass water-gauges and mercurial pressure-gauges shall be required to be fitted to the boilers, to entitle the vessels to a license to ply with passengers.

7. That, in the event of the surveyor having information that any boiler be deteriorated in strength, or unsafe at its working pressure, in the interval of his periodical surveys, he shall be empowered by the board, on his representation, to examine it; and in the event of the boiler proving faulty, the board shall suspend the passenger license, until satisfied of the safety of such boiler.

8. That no steamvessel be permitted to ply which is not furnished with a binnacle and compass, in good order.

9. That, after an assigned period, no sea-going steamvessel, which carries coals on the tops, or about the sides of the boilers, shall be entitled to a passenger license, unless the boilers be protected by a shell of metal, or other sufficient security.

10. All river steamers to carry one effective boat—coasting and channel steamers, two, or three boats, according to their size—and ocean steamships, four boats—as a minimum.

The surveyors to ascertain that these boats be kept in serviceable condition, and ready for use on emergency.

11. All steamers to be provided with sufficient hoses to convey water to any part of the vessel, with a serviceable outfit of water-buckets; and a moveable fire-engine to be carried in all coasting, channel, and ocean-going steamers.

The proposed system of registration should include a classification of steamers; and as the character to which each vessel would be entitled in

its class would depend on its general state of efficiency, we are disposed to think that many other important requisites for attaining the utmost practicable degree of security would gradually be adopted by owners, without compulsion; such as water-tight bulkheads in new vessels; powerful extinguishing pumps, worked by the engines; connexion of the condensers with the bilge-water; disengaging apparatus for the paddle-wheels; heavier and more effective ground-tackling, &c. The publication of accidents, and of their causes, would also warn steamvessel owners, commanders, and engineers, and instruct them how to guard against disasters.

Abstract of the laws and regulations of foreign states.

FRANCE.

Cast-iron boilers prohibited.

High-pressure boilers to be proved by the hydraulic press, to at least three times the degree of pressure at which it is intended to use the steam. The owners to find the press and labor.

Rectangular boilers exempted from proof when used to raise low-pressure steam, *i. e.*, steam not exceeding 7 lbs. pressure per square inch above the atmosphere.

All cylinders, and cylinder jackets of steam engines, whether using high or low steam, to be proved to three times the working pressure.

The above rules apply to all engines and boilers, whether employed on land or water. The following are special laws as to steamvessels:

1. No steamer to ply until certified to be seaworthy in hull, boilers, and machinery; to undergo subsequent inspection every three months.

2. No certificate granted, but on the express condition of the engine-man being a skilful mechanic, and possessed of sufficient knowledge to maintain the machinery in good order, and repair it if necessary. No fireman allowed to act as engine-man, but to be subject to the order of the latter. The engineer to observe precautionary rules, to be hung up for his guidance in the engine-room.

3. Every boiler to be provided with a water-float and index, two glass water-tubes, three gauge-cocks, and an open-ended mercurial steam-gauge. It is also recommended to apply a safety-pipe, with a whistle at the end of it, to give notice when the water is too low.

4. Two safety-valves required to each boiler, of not less than a certain area. High-pressure valves to be loaded by means of a lever; low pressure with a solid weight upon them. All additional weight, after the survey, prohibited. The prescribed pressure stamped on the valve-boxes.

5. Two disks of fusible metal to be fixed on all boilers, in the steam-space or chest, having different degrees of fusibility, and different dimensions; the smallest and most fusible to have an area equal to that of one of the safety-valves; the largest and least fusible to have an area equal to four times that of the valve. These disks are supplied, after proof of the boilers, and according to the pressure at which it is intended to work: all change of them prohibited, and duplicates to be carried in every vessel.

6. Instructions given for the management of the fires, and for the conduct of the engineer and captain reciprocally, when the vessel has to stop, &c.

7. Captain to be personally responsible for all accidents arising from excessive velocity; and owners, for all accidents which may arise from the nonobservance of the laws and regulations.

8. A ruled log-book or diary, to lie open in the cabin, in which passengers are requested to write their observations concerning the events of their journey and the performance of the vessel: these books to be examined by the police authorities and commissioners on their periodical visits. In the cabin is to be placed a table, indicating—

1. The mean duration of a trip.
2. The time allowed for stoppages.
3. The maximum number of passengers permitted by the law.
4. The right given to passengers to inscribe their remarks in the log-book.

9. The minutiæ of the *procès verbaux* by the commissioners, &c., are particularized.

10. Tables of the elastic force and temperature of steam, from 1 to 50 atmospheres of pressure, are given, together with the areas of safety-valves and fusible disks proper for each pressure, as determined by a commission of the Royal Institute.

HOLLAND.

Surveyors are appointed to test the strength of all boilers according to a prescribed scale, on whose favorable report permission is granted to work.

Two safety-valves, at least, are required to each boiler; and the mode and degree of loading them determined.

Leaden plugs of certain dimensions are to be fixed in the boiler-plates over the furnaces.

Cast-iron boilers are prohibited, except they be made to a given scale of substance; and various regulations are enacted, as to the position of the boilers in the vessel, their separation from the cabins, &c.

Surveys to be repeated annually; and special surveys to be made on demand or occasion.

Certificates of seaworthiness are renewed or refused, according to the reports of surveyors.

BELGIUM.

The laws in this country are very similar to those of Holland.

EXTRACTS FROM LETTERS AND COMMUNICATIONS ADDRESSED TO THE BRITISH COMMISSIONERS OF STEAMVESSELS.

Mr. J. C. Shaw, engineer and marine manager to the City of Dublin Steampacket Company, Liverpool.

"2. No accidents have ever occurred in any of the company's vessels from explosion or rending of boilers. We construct many of our boilers, and repair all of them, preferring and now constructing them only of a cylindrical

shape, with the external flues of similar form, or as nearly so as we can get them.

"Our boilers are all separate, each containing its own water, and the steampipes having separate valves to shut off the communication with the other boilers. The advantage of this plan is forcibly evidenced in the case of the collision between the 'Thames' and the 'Shannon.' The 'Thames' *must have gone down had the water in the different boilers not been distinct.*

"3. My opinion is, that accidents to boilers are referable to defective construction, carelessness, neglect of proper repairs, and the absence or mismanagement of proper apparatus for the safety of boilers. The boilers of the "Fingal," which plyed in 1835 from Liverpool to Dublin, were so weak that they had to be shored between the deck and the top of the boilers, which expanded and contracted like a pair of bellows. Had a system of inspection and surveying been then adopted, this vessel never could have been suffered to have gone to sea. Tabular or flat-sided boilers are rarely sufficiently stayed.

"4. Steamers are lost as often from weak and defective hulls as from defective machinery. Our experience has taught us the importance of substantial construction of every part of the vessel which, with the engines, are built to a written specification.

"5. The engines and boilers of steamers are certainly not overhauled and repaired so frequently as they should be. Nothing can be more slovenly, more hurtful to the interests of the owners of steamers, or more dangerous to the public, than the condition of many steamers. Experience has shown the value of a system of overhauling and repairing our machinery, the most minute, frequent, and at the same time most advantageous and economical to the company. The arrival of any one of our vessels is instantly notified at the office, both at Liverpool and Dublin: the foreman of the boiler-makers and the master engineer immediately go on board, and are required, within two hours, to make a report in writing to me of the actual state of the engines, boilers, and all their apparatus, by filling up printed forms prepared for each. The hull is inspected by a shipwright. Each vessel is placed on the gridiron at least once in every three months, merely to sight her bottom. The head fireman, having extra wages, is fined 10*s.* in the event of his not pointing out even if a rivet-head has sprung, or any other defect in his boiler during his last voyage.

"6. The safety-valves in all our vessels are so arranged that the engineer can raise them to ease his boiler, but cannot load them beyond the assigned pressure. Eight pounds per square inch is the highest pressure we employ in our new cylindrical boilers; but they would be equally safe with twelve pounds as the tabular with four pounds on the square inch. We have vacuum-valves, glass water-gauges, and a mercurial pressure-gauge to all our boilers. The blowing-off and feed cocks are of brass. In making new engines, they are, also, subject to a written detailed specification.

"7. We now build no vessels without iron water-tight bulkheads.

"8. The nature of the lights carried by steamers should be defined by a positive law, and all sailing vessels should be compelled to show a light at night in rivers, pilot waters, or on the ocean. Numbers of sailing vessels are constantly lying to in the track of the traffic; they rarely carry a light, and a steamer has to look out for them, and take care of both. The American packet-ships, it is said, never carry lights in the channels, and

constant accidents occur from the want of a clearly defined and positive enactment on this subject.

"10. It is my decided opinion that an authorized system of frequent inspection both of the hull and machinery of steamvessels would greatly contribute to the safety of the public, and be attended with positive economy and advantage to companies, as it would contribute to give passengers a greater confidence in the security of life and property on board.

"The hulls should be surveyed while building, to see that it is done according to the specification for their tonnage, and that bad timber may be discovered and rejected. Lloyd's Rules might do as a minimum, but would be better if stronger. A new vessel should be periodically surveyed, the frequency varying with the age.

"Boilers, after being in use four years, should be surveyed very frequently. After five years' running, the boilers, timbers in their wake, deck-beams, and ceilings, all require looking to, lest they might be injured; the middle of the vessel, which should be the strongest, becomes the weakest, after so long a period of working, in consequence of the skin being charred from constant heat."

"I enclose you two certificates of the perfect condition of the ceiling of the 'William Huskisson,' in the wake of the boilers, although those boilers have been in use since the 9th of May, 1834. Before I adopted the plan of covering the ceilings of our steamers with lead, it invariably happened that I had to renew that portion of the hulls every time an old boiler was taken out; for the planking in the wake of the boilers was so charred as actually to tumble to pieces when our men were taking off the sheet iron that covered it: thus, it is evident that the middle part of the steamer, which ought to be the strongest, became the weakest, long before it was necessary to lay her up for new boilers. In addition to the great value of lead as a protection to the substance of a steamvessel, its utility as a preventive to *fire* admits of no doubt; for it is very evident that the heat in the bunkers must be intense enough to *melt* the lead before the ceiling which it covers can be ignited."

Certificate respecting lead linings on the inside of steamvessels, near the boilers.

Lloyd's Register of British and Foreign Shipping.

This is to certify, that I, the undersigned, surveyor to this society, have this day examined the steamboat "William Huskisson," in the North graving dock at this port; that I found the boilers, which had been in five years, had been removed, and the ceiling completely exposed; that the heat from the boilers had not at all affected the plank of the ceiling, which is quite fresh and in good repair. As witness my hand.

J. BAYLEY, *Surveyor to Lloyd's.*

LIVERPOOL, *April* 1, 1839.

I hereby certify, that I have examined the ceiling in the wake of the boilers of the "William Huskisson," and found it perfectly sound, after having remained in five years. I also found, after I had removed the sheet iron, that the lead under the same was quite sound, and would do again if

it had not been torn by disentangling it from the iron. The sheet iron is completely decayed and unfit for use.

JAMES McARDLE,
Foreman and carpenter to City of Dublin Company.

APRIL 1, 1839.

C. W. Williams, Esq., managing director of the City of Dublin Company, Liverpool.

"1. That the hull be divided into, at least, five separate compartments, by four iron-plate, water-tight, bulkheads or partitions, so as effectually to confine the water or fire to the compartment in which either may have originated. The importance of this is unquestionable; and, in illustration of its value, I may state that the steamer 'The Manchester,' which, many years back, sunk between Dublin and Holyhead, would have been perfectly safe had she been provided with these bulkheads. The injury sustained was in the bottom, about midships, in consequence of having got on a sand-bank near Dublin; and, from want of a sufficient graving dock or slip in that port, the examination and repairs could only be effected by banking the vessel. These repairs, it is supposed, had been insufficient, as when half-channel over, the vessel suddenly filled. It is evident that a very small addition of buoyancy would have saved the vessel, since she settled until her main deck was on a level with the water, and remained in that position a considerable time before she disappeared.

"Since that time, several large steamers have been lost by reason of water or fire, which, though at first confined to a small section of the vessel, yet, by passing throughout the whole, all efforts to save the vessel were rendered unavailing.

"2. The substitution of copper or composition bolts, with nuts and screws in the fastening of the planking and other parts, in place of the timber tree-nails, the use of which should be entirely exploded.

"3. The addition of hanging iron knees, properly constructed, with stays, under the main and middle deck beams, wrought and fitted with care, and according to prepared drawings; also, a continuous connexion of iron staple knees, by which the entire series of deck beams are firmly bound together and to the sides of the vessel, by which the whole is connected, endwise, in the most effective manner.

"4. The adoption of an improved larboard strake, cut from a solid balk, and fitted to the rabbet of the keel. Mr. Lang has lately done much towards introducing this valuable improvement.

"5. The attaching the sister kelsons and sleepers, on which the engines and boilers are placed, firmly to the bottom of the vessel, by a proper system of bolts, passed through the floorings and bottom planking, and by lateral stayings, these sister kelsons passing the entire length of the vessel. This mode of strengthening a steamer is very little in use.

"6. The introduction of powerful longitudinal wrought-iron bolt-stays, four at least, and from one and a half to two and a half inches diameter, running the entire length of the main deck, and through all the main deck beams, properly secured to each, with washers and cotters before and aft of each beam; so that each deck beam be not only thus tied together, but that each shall bear its due proportion of any strain of the vessel, endwise, in a

heavy sea. These iron longitudinal bolt-stays have been introduced, with great advantage, into several steamers, which, previously, had worked considerably in a sea-way.

"7. The introduction of an inner lining of sheet lead under the lining of sheet iron, and next the skin of the vessel, to prevent the desiccation and charring of the timber bottom and sides, which the excessive heat and decomposition of the fine powder of the coal, in the neighborhood of the engines and boilers, frequently occasion. This under sheeting of lead has been found an effectual remedy.

"8. The use of iron in the various hatchways, ceilings, and scuttles, instead of timber, which latter weakens the deck of a vessel, whereas the former strengthens it.

"9. The introduction of longitudinal cast-iron beams, in lieu of wood, the entire length of the boiler hatchways, and to which is attached a wrought-iron plate deck, the full size of the boiler-hatchway. These iron beams secure that vulnerable part of the deck from fire, contraction, or sinking. The wood beams and deck usually adopted over the boilers contract instantly, and thus admit water to the top of the boiler.

"10. The preparing the entire timbering, planking, decks, &c., on Kyan's or other anti-dry-rot principle, thus securing the greatest durability to the hull. This steeping process is effected in the builder's yard, and under the special superintendence of a competent individual on the part of the owners.

"The mere enumeration of these few items will sufficiently show the importance of a detailed specification, and the more so as the construction of ships of a large class, and intended for the high seas (particularly as to the nature, strength, and extent of their fastenings), is so essentially different from that of ordinary merchant shipping.

"The details of a specification, and the adoption of all or any of the above-mentioned items, will, of course, be governed by the kind and class of vessels to be constructed, and the peculiar service to which they may be destined. I have hitherto spoken but of large vessels with great power, and intended for the open sea.

"The directors of steam companies being necessarily unacquainted with these matters, and obliged to rely much on the skill of others (and who are too often selected from the mere circumstance of having made the lowest building tender by the ton measurement), the introduction of a system of periodical surveys and licenses, by duly appointed and qualified officers, cannot fail of becoming the best security to steam companies, and the best guaranty to the public.

"Under the head of 'night-signals,' I would observe that, through the want of some recognised and authoritative system, great inconvenience, risk, and injury, have been sustained. The plan adopted by the Dublin Company, who make 800 voyages, or 1,600 crossings of the channel, annually, has for many years been found fully adequate to the prevention of collision. It consists in having, in addition to a bright light at the foremast-head, one other fixed light in front of each paddle-box: thus presenting a triangle of lights with the apex uppermost. Again, from the angle at which these fixed lower lights are placed, both can only be seen from the approaching vessel when directly ahead, or within a given range of that direction. These lower paddle-box lights being also of different colors, it is easy to distinguish how the head of the steamer lies, and thus to avoid collision."

"I may here be permitted to add, that, as the system of the British Government should be to encourage private enterprise in promoting steam navigation, so it would prove the best means of providing an effective and adequate force of steamvessels in case of war.

"Other nations, not having a steam commercial marine, are obliged to maintain a sufficiency of national steamships—a system which must be attended with great expenditure, but which is inadequate to the keeping pace with the progress of steam-navigation. Great Britain, on the other hand, by promoting steam-navigation for mercantile purposes, and securing to it the utmost efficiency, strength, and perfection, is laying the surest foundation of national protection in the event of war. The large class steamships now constructing are all capable of being powerfully armed; and, at almost a moment's notice, a fleet of steamvessels may be obtained adequate to any service the Government might require.

"As a mighty means, then, of strengthening our national defence, for the sake of the public, for the better security of the underwriters, and as an encouragement to builders, engineers, and owners of steamships, an authoritative, sufficient, and compulsory system of survey is, on every ground, desirable.

"*On iron steamvessels.*

"In suggesting what may appear to be improvements in the construction of steamvessels, I should speak of iron hulls. On this head, I have no hesitation in recommending iron vessels as far as second-class size; beyond that I have no experience, and experience alone must decide the question as to steamers of the largest class.

"I was the first to construct an iron sea going steamer of 100-horse power, having had the 'Garryowen' and 'Lansdowne,' each of 100 horse power (now plying on the river Shannon), built of iron for the Dublin Company. As far as experience has enabled me to speak, I do so with confidence as to the strength, durability, and general efficiency of iron-built vessels. The following reports from the commander and engineer of the 'Garryowen' are the best evidence I can offer on that head:

"'The commander of the 'Garryowen,' Mr. Bingham, writes thus in reference to the great hurricane of January last:

"'We went ashore about two cables' length to the eastward of the pier (Kilrush), and struck very heavy for the first hour; the ground under our weather bilge was rather soft clay, covered with shingle and loose stones, some of them pretty large. Under our inside or lee-bilge the ground was very hard, being a foot-path at low water. I was greatly afraid she would be very much injured by it in her bottom, but I am happy to say she has not received any injury; in fact, her bottom is as perfect and as good as on the day she left Liverpool; not a single rivet started, nor a rivet-head flown off. If an oak vessel, with the cargo I had on deck, was to go on shore where the "Garryowen" did, and get such a hammering, they would have a different story to tell.'

"The 'Garryowen' was built by Mr. John Laird of Birkenhead, near Liverpool.

"The engineer of the 'Garryowen,' Joseph Parry, writes thus, after the hurricane:

" 'We found, while trying to get the vessel off, she would not fall into her dock, although we cleared away the bank, within a plate and a half of the the keel. She would not move even then at high water, so we cleared away the bank above 40 feet aft, and 30 feet forward, leaving nothing to bear her up but the strength of the vessel; and although there was such a length of overhang, yet there is not a rivet started or seam open, nor the least injury received whatever. Out of 27 vessels that got ashore that night, the "Garryowen" is the only one that is not damaged more or less.'

"I can add also, that having last year had to take out the boilers, I found the skin of the vessel in perfectly good condition, and no appearance of rust."

Specification for building a steamvessel of 600 tons burden, contracted and agreed upon, &c., in a substantial and workmanlike manner, and with good sound and proper materials of every kind, according to the conditions, dimensions, and scantling, as follows, viz:

Length from the fore part of the stem-head, to the aft part of the stern-post, along the keel, — feet.

Breadth from outside to outside of the plank in midship, — feet.

Depth in hold, — feet, — inches.

The keel to be of elm, in not more than five pieces, one foot two inches square in midships, 12 inches at the fore part, and at the after part of the rabbet of the post, 11½ inches; the scarphs four feet nine inches long, tabled one into the other, laid with flannel, and bolted with six bolts of one-inch copper; the lips of the said scarphs not to be left more than four inches, and the rabbet to be taken out as per annexed drawing, for a solid garboard strake.

The stem not to be more than two pieces of sound oak, and free from defects of any kind, to be sided at the head 14 inches, and to taper to the fore foot to the bigness of the keel.

The scarphs to be four feet long, tabled together, and laid with flannel; secured with six bolts of one-inch diameter; two of the bolts to go through the false stem or apron, and clenched thereon, the rabbet to be taken out of the middle.

The apron to be sided 14 inches, and to be of the same breadth as the stem; to be dowelled and bolted with five copper bolts of one-inch diameter.

The stemson to be sided same as the main stem, and overlaunch its scarphs, and secured with one-inch copper bolts every two feet.

The knight-heads to be sided 12 inches, fayed and dowelled to the apron, and bolted through, and to each other with five copper bolts of one inch each, well clenched, of sufficient length to take a bolt in the hook below the lower deck; the upper bolt not to come within nine inches of the bed of the bowsprit.

The stern post to be of sound oak, of the best kind, and free from defects, to square at the wing transoms 14 inches, fore and aft on the keel one foot eight inches; abaft the rabbet at the wing transoms ten inches, and on the keel 14 inches; the top end of the tree to be worked upward; the aft side of the stern post to be grooved and hollowed to receive the rudder.

The inner post to run up to the under side of the wing transom, and conform to the size of the main post when trimmed with six dowells into the main post.

The wing transoms to be sided in the middle 14 inches, and moulded 16 inches; no chocks admitted on the aft side; to be secured with two copper bolts of one-inch diameter through the post; also four lower transoms, sided from ten to eight inches, with one bolt in each of one-inch copper.

The fashion pieces to be sided eight inches, and dowelled to each end of the transoms.

The room and space of the timbers to be two feet four inches.

The floor timbers in midships to be sided 14 inches; half floors, sided 14 inches; forward and aft 10 to 12 inches; for 70 feet in midships to be solid, fayed together with close joints, all dowelled and felted between each joint, and bolted together with inch-iron bolts, without any fillings; every other timber to be bolted through the keel with copper bolts, and well clenched on the under side, the space between the floors and lower futtocks, before and abaft the above, to be fitted in solid with Dantzic pine, from the keel to three feet above the floor heads; the fillings to be two inches less moulding than the frame, so as to leave a sufficient water course on the inner side; the whole to be calked both within and without, from the floor-heads downward.

The lower futtocks to be sided 12 inches in midships for 70 feet, diminishing forward and aft to 10 and 11 inches, and moulded at their heads to $9\frac{1}{2}$ inches, to scarph on floors, with two cogues and bolts in each scarph.

The second futtocks to be sided 10 inches, and moulded at their heads.

The third futtocks and top timbers to be sided 8 to $7\frac{1}{2}$ inches, and moulded at plank shear $6\frac{1}{2}$ inches; all the frame to be English or African oak, well squared, the butts of timbers to be close and dowelled, or cross chocked; every other timber is to be framed together; the lower futtocks to be fayed and dowelled to their respective futtocks, second futtocks, fayed and dowelled to their respective lower futtocks, with two dowells in each scarph, and bolted with $\frac{3}{4}$-inch square iron; before the lower futtocks are bolted together, the faying surfaces are to have felt, well tarred, laid between them; the fillings are to have felt on each side to prevent infection from or to the timbers, and before the plank of the bottom is worked; the joints of floors, lower futtocks, and fillings, are to have a thread of spun yarn driven against the felt, payed well with pitch and tar, so as to leave that part of the bottom perfectly water-tight, even without the planking, and the plank that comes in the range of the upper edge of the fillings to have felt underneath all, fore and aft; the frame to be above the solid work, according to the annexed drawing of the distribution of the frames; the frames to be put together so as to have three timbers between every two butts in the drawing.

There must be sufficient dead-wood forward and aft for securing the half timbers, of a height to answer the run of the kelson, to give proper shifts to the scarphs of the keel and to each other, and bolted every two feet two inches from the fore and aftermost flooring, through the keel, stem, and stern post, with $1\frac{1}{8}$-inch copper bolts, well clenched thereon; the deadwood sided 10 inches, at the stepping 13 inches; the deadwood knees to run up to the lower transom; the lower arms to be nine feet long.

The hawse pieces to have three on each side, sided 10 inches, of a proper length and breadth to form the bow; the hawse-holes must be taken out sufficiently to allow of an iron flaunch, 10 inches diameter, and $\frac{1}{8}$-inch thick, with thin lead underneath.

The main kelsons to be of pitch pine, sided 15 inches, and moulded 16 inches, bolted through the floors, and keel with $1\frac{1}{8}$th bolts of Grenfell's

patent yellow metal, clenched on a ring on the under side of the keel. The scarphs to be seven feet long, tabled together with three dowells in each, and two $\frac{7}{8}$ths of an inch iron bolts in each upper lip through the other piece.

Two sister kelsons on each side of the kelson, sided 16 inches of the longest possible lengths, so that they may not scarph under the engines. The scarphs to be five feet long, dowelled and bolted together, giving good shifts to each other; to extend as far both forward and aft as the rise of the floor will allow them to be brought: dowelled to the floor timbers, to prevent lateral movement, and bolted through with one-inch bolts of Grenfell's metal.

Plank at bottom; garboard strake to be of elm, eight inches thick, dowelled and fitted to the sides of the keel, as per drawing annexed; bolted through it, and to each other at about four feet apart. The plank from the keel to the bilge of four inches elm. The bilge to be in three strakes of five-inch elm, from the bilge to the first futtock heads of four-inch elm, from the first futtock-heads to the bends to be four-inch Dantzic pine; bends or wales in five strakes of four-inch African oak nine inches wide, secured with an extra thorough bolt with screws and nuts in every other timber, and through the clamps inside.

Throughout the vessel it will be required that all the planks shall have six feet shifts, and not less than three strakes between every two butts on the same timbers, to have a thorough bolt in every butt with a screw nut inside, of Grenfell's metal.

Copper bolts: all the bottom planks to be secured with three copper bolts in every frame instead of treenails.

Bilge bolts: one of the $\frac{7}{8}$th bolt of Grenfell's metal through every timber of the bilge planks to have a screw and nut on the inside bilge plank.

Sheer strakes—in two breadths of four-inch African oak, let on the timbers five-eighths of an inch all fore and aft, to shut in between these and the wales, with three and a half and four-inch Dantzic pine.

Upper-deck shelf-pieces, to receive the ends of the upper deck, beams to be of African oak six inches thick, and fifteen inches wide, let on the timbers one inch, and bolted through from the outside with seven-eighth inch iron screw, bolts and nuts.

Clamps—in five strakes of four inch African oak, wrought opposite the outside wales, let on timbers five-eighths of an inch.

Bilge planks, on floor heads in three strakes of four-inch African oak.

Crutches, aft, of English oak, sided nine inches, bolted with one inch copper bolts.

Hooks—four hooks forward of English oak, upper and lower deck hooks sided ten inches, each arm six feet long, lower hooks sided nine inches, bolted with $1\frac{1}{8}$ and one inch copper through from outside.

Beams—the upper-deck beams of English and African oak, only three feet six inches apart; sided nine inches, and moulded in the middle ten inches, cogued or dowelled at each end, and bolted to the shelf pieces; all secured also with horizontal iron staple knees.

Carlings—no carlings or ledges, but the whole of the beams to be placed sufficiently near to support the deck, and sufficiently deep to receive long fore and aft iron bolt binders.

Upper deck staple-knees—horizontal iron staple-knees all fore and aft, between all the beams $3\frac{1}{4}$ inches wide, and $2\frac{3}{4}$ inches thick, with an iron hanging-knee to every other beam, $3\frac{1}{4}$ wide by three inches thick; secured

with one inch and $1\frac{1}{8}$ inch iron screw-bolts and nuts, both to the beams and sides of the vessel, as per drawing annexed.

Main beams for paddle wheels, of African oak, sided eighteen inches, and moulded twenty-one inches, secured at each end outside with a large iron knee $4\frac{1}{2}$ inches square; the arms five feet and six feet long, with diagonal stays to each, of $3\frac{1}{4}$-inch diameter; also an iron hanging-knee inside to each beam end, of four inches square at the throat, bolted with $1\frac{1}{8}$ inch, $1\frac{1}{4}$-inch iron screw-bolts and nuts, as per drawing.

Spring beams, for the support of the paddle-shaft, of African oak, ten inches sided, and two feet three inches deep.

Boiler beams—fore and aft beams for the boiler and hatch of cast-iron; also the hatchway coamings of cast-iron, as per drawing.

Water-ways—upper deck water ways of African oak, six inches thick, and ten inches wide, bolted through from outside with seven-eighth inch iron bolts, and clenched thereon.

Upper deck—planks of $3\frac{1}{4}$ inch yellow pine, six inches wide, secured with six inch nails of Grenfell's patent metal.

Lower-deck shelf-pieces, to receive the ends of the lower-deck beams, of African oak six inches thick, and fourteen inches wide, let on the timbers, and bolted with seven-eighth inch iron screw-bolts and nuts.

Lower-deck beams, of English and African oak (alternately), sided ten inches and moulded ten inches, secured at each with two bolts, and dowelled to the shelf-pieces, with horizontal iron staple knees to every beam, as in upper deck, and a hanging-knee to every other beam.

Lower-deck knees of the same size as the upper deck, and secured with one-inch and $1\frac{1}{8}$ inch iron screw-bolts and nuts.

Lower decks, of three inch yellow pine, seven inches wide, and nailed with six inch iron nails.

Counter timbers, of English oak, sided at the foot eight inches, and at the head six inches; the side counter timbers to be well kneed to the ends of the wing transom, with oak knees, the others to be scored and tailed half their thickness in the wing transom, with a short timber between each, to strengthen the lower counter; to birth up the lower counter with $3\frac{1}{2}$ inch Dantzic pine; copper bolted instead of treenails; and the upper part of the stern planked with $2\frac{1}{2}$ inch, rabbetted; to have an iron strap seven-eighth inch thick, and three inches wide on the foot of each counter timber, to run down to the second transom, well bolted to each.

Transom beam, of English oak under the cabin windows, let on to the counter timbers, and secured at each end with an iron standard knee, to run up the side five feet, and along the transom four feet, bolted with $1\frac{1}{8}$ inch screw bolts; also an iron knee on each end of the wing transom, to run five feet up the side, and put on the transom, $3\frac{1}{2}$ wide by three inches thick, bolted with iron screw-bolts of $1\frac{1}{4}$ inch diameter.

Poop—the vessel to have a poop deck four feet above the main deck, as far forward as the after end of the boilers; the deck transom of English oak, sided and moulded eight inches, with a rabbet on the fore part, proper for the deck plank, scored and bolted to each counter timber with iron screw-bolts and nuts; the outside of the poop to be planked with $2\frac{1}{2}$ inch pine; shelf-pieces of four-inch Dantzic pine; ceiling below the shelf-pieces of three-inch Dantzic.

Poop deck beams—every other beam of English oak, the rest of Dantzic pine, sided seven inches and moulded six inches, dowelled and bolted to the stringers, with horizontal staple-knees and screw-bolts.

Poop deck water-ways, of four-inch Dantzic pine, bolted through from outside with three-fourths inch irons, deck plank of three inch yellow pine, five inches wide, copper nailed, with wood stanchions of oak, and rails round the poop.

Catheads—of English oak, ten inches sided and eleven inches moulded, of sufficient length to let the anchor hang clear of the bow.

Pall bitts—of African oak, fifteen by sixteen inches. Carrick bitts, sided eight inches and moulded twenty inches.

Windlass—of African oak, with an iron spindle all through, of four inches square, pallwheel and palls, with substantial brass boxes for the spindle-neckings, with a patent purchase.

Rudder braces—to find and fix three pair of mixed metal braces, $3\frac{1}{2}$ inches wide, bolted through the stern post and to each other, of Lucas patent.

Rudder—the main piece of English oak, well grown, so that the braces may not weaken it; the other fitting-up of pine, all well put together, and bolted with Grenfell's patent metal, every three feet, with one-inch bolts; the main piece to be sixteen inches diameter.

Mast partners, steps and bowsprit, heel bitts.

Paddle-boxes—the king post of African oak, six inches by ten inches wide; diagonals of African oak, four inches by nine inches, all well kneed to the spring-beams; also two bolts of $1\frac{1}{4}$ inch iron, drove up through the spring-beams, secured with a nut on the diagonals; the rim pieces of English oak, five inches square, planked up to the rail with three-inch Dantzic pine, and above with $2\frac{1}{4}$ inch, with flappers on the top, and also before and abaft, so as to allow a heavy sea to escape.

Cutwater well secured to the bows by two wood cheeks, headrails and supporters, handsomely wrought, with a neat carved bust or demi-figure.

Stern—to build a handsome stern and quarter galleries, with carved taff-rail and moulding, finished in the lightest manner possible, agreeable to a vessel of her class; also sham quarter galleries.

Waiste, from forward to the poop, of $1\frac{1}{2}$ inch pine, six inches wide.

Calking—the vessel to be well and carefully calked all outside with oakum, picked out of good junk, and payed with pitch up to load water-mark; above load water-mark, to be payed with white lead and putty; the upper and lower decks also carefully calked and payed with pitch.

Joiner's work—the vessel to be planed outside down to the sheathing copper, between decks and under side of main deck; also the beams, shelf-pieces, &c.

Forecastle, fitted up with berths for the seamen, with a bulkhead at the aft part; two houses before the paddle-boxes for the lights, and store-rooms on deck and the deck work in general.

Painters to paint the vessel from the copper, up, outside and all the deck work, with three coats of oil colors; also the forecastle and berths with three coats; all the main deck scuppers of lead, with sheet lead under the bowsprit and hawsepipes.

Masts—one entire set of masts and spars.

Boats—two boats, copper-fastened and painted, with iron quarter davits and blocks.

Insurance—the vessel to be insured while building, and delivered safe afloat.

Solid frames for bulkheads—the frame timbers to be made solid and water-tight, three feet wide (at each iron bulkhead) up the sides to the upper deck, each joint to have felt between, also felt on the out and inside of the frames before the planks are wrought, so that the vessel may be divided into *five water-tight compartments*, by four iron bulkheads.

Station for the water-tight bulkheads—the first bulkhead will be about the aft part of the forecastle, the second at the fore part of the engines, the third at the after end of the boilers, and the fourth bulkhead at the fore part of the water tank, which tank will be placed close aft.

These iron bulkheads, and the four longitudinal iron boltstays, under main deck, may be provided by builder or owner; the attaching them to the vessel to be at the expense of the builder.

All the materials to be of the very best quality, and put together in a good, substantial, and workmanlike manner.

The whole of the above work to be carried on under the free inspection and superintendence of a competent individual, appointed by the owners, to secure due attention to all the details.

C. W. WILLIAMS.

LIVERPOOL.

On the importance of building steamvessels to a detailed specification.—By C. W. Williams, Esq., Liverpool.

GENTLEMEN: In my former communication, I omitted stating the cost of those improvements and additional strengthenings which I have recommended on the experience of the Dublin Steam Company, arising out of the building, overhauling, repairing, general maintenance and employment of their numerous steamvessels, during fifteen years. That I may enable you to appreciate the value and effect of such of those improvements as could not be intelligible by mere description, I now send you a few hastily prepared diagrams; sufficiently accurate, however, for the purpose of explaining the construction of the *hanging-knees*, *staple-knees*, *garboard-strake*, *solid flooring*, and *longitudinal iron boltstays*, referred to in the specification before sent. To these (when we come to estimate the extra expense of a vessel constructed under such a specification, beyond what is usual under ordinary contracts, unless specially required and paid for) may be added the following, viz: the adoption of copper ragged *dumps* or *bolts*, *copper* or *composition bolts*, *nuts*, *washers*, *and screws*, in place of *wooden treenails*, which are entirely dispensed with; the substitution of *oak* in place of *pine* in many parts; the additional *size* and *number* of the "*thick stuff*" pieces; additional scantling, lengths, numbers and boltings of the *sister kelsons*, and *sleepers;* the adoption of *deck-beams* throughout; rejecting entirely the principle of "*carlings;*" *iron deck*, and *boiler beams*, and *iron-deck plates*, in place of *timber*, in the required places; *improved* rudder principle and *fastenings; iron* coamings, &c., in place of *timber; water-tight iron-plate bulkheads*, with *solid* framing in the wake of each bulkhead; the preparing the timber by Kyan's or other principle; with other extra work, as stated in the specification. The additional cost in the price of a steamvessel, say of 600 tons, by the adoption of the items above enumerated, has been estimated at 3*l.* 10*s.* per ton, builder's measurement.

You will observe, I am not to be understood as stating that all these items are *additional* to what has been adopted by others; many of them are now introduced by shipbuilders; others of them by special agreement, and paid for separately, as not being included in the "rate per ton," at which they calculated the vessel to be built. Others again are adopted, as for instance, iron-knees, yet not with the same number, strength, accuracy of work, or number and character of boltings; but which would be adopted, if required, and paid for as extra. In fact, the not adopting such improvements and additional fastenings cannot be set down as deficiencies or omissions on the part of the builder, inasmuch as they are still considered as extras, and are not included in the ordinary quantity of work to be done, when a given rate per ton is stated as the builder's price.

The mere enumeration alone of so much additional work, and which may be modified or even omitted without any imputation on the builder, is sufficient to show the utter fallacy, and even risk, arising out of the custom of merely calling for tenders, *by the ton*, from shipbuilders, and then laying those tenders for decision before a number of gentlemen sitting in committee, and who necessarily must be ignorant of the vagueness of their proceedings on the details of ship-building; and of the comparative cost, necessity, or importance of the several items which may or may not be included in those tenders. Tenders are thus taken into consideration without any *specification* whatever, and not unfrequently before the length, depth or breadth of the vessel has been determined upon. Such a proceeding, though of every day's occurrence, may not inaptly be compared to that of requiring an architect to give a tender for building a house, without any further particulars than that "all the materials were to be of the best description, and all put together in the most workmanlike manner," and that the dimensions were to be so many feet deep, so many in front, and so many in height.

In the case of tenders being sent in for building a steamvessel, and the character of the builder offering the lowest tender, by the ton, being respectable, such tender, as a matter of course, is accepted, the committee of owners having no other possible mode of testing the merits of the respective tenders; yet the differences between the several modes of building and fastening a large steamer, which even respectable builders would adopt or think sufficient, are greater than have hitherto been even thought possible, when we take into consideration seaworthiness, strength, and durability.

It were invidious to allude to parties by name; but the fact is within my own knowledge of a tender having been accepted for building a steamvessel, merely because it was 5*s.* per ton less than that of rival tenders, although the builder was wholly inexperienced in the construction of such sized steamvessels, and knew nothing of, and did not adopt, any of those peculiar modes of putting together and fastening, which would have influenced the price more than ten times the difference which decided the question.

This can only be remedied by furnishing such detailed specifications to the shipbuilders as would be done in the case of contracts for public buildings on land; and when we consider that *one great object of a steamvessel is to provide safe and speedy conveyance for human beings*, and that tens of thousands of pounds must be spent upon her hull, fittings, and machinery, in order to attain that object, surely there is greater reason why a *specification* should be furnished for its construction, than for that of a house or a cottage. The same remarks apply with equal truth and force to the engines, boilers, and machinery.

With the view of aiding in this essential work, by which steam navigation will hereafter be benefited as much perhaps as by any scientific discoveries yet in store, and with the view of promoting the objects of your commission, I have ventured to present a *specification* for the hull, including those additional matters which the present state of steamship building has sanctioned.

I have stated that this specification is not presented as perfect, or as an unerring or fixed standard; quite the reverse: it is but the beginning of what, in my estimation, will hereafter become the best guarantee to the public and the owners, and prevent steam companies from being blindly led into the construction of steamvessels on faulty principles, or of insufficient strength; and it supplies some standard by which the public may be guided in its choice of steam conveyance, rather than by the *gildings, gothic mouldings, mirrors, paintings, and other attractions lavished on the cabins of the advertised* "SPLENDID and NOBLE VESSEL," to the neglect of the manner in which the frame is put together and strengthened, and upon which the safety of the vessel depends. In the preliminary arrangements for the construction of a bridge or a building we employ a civil engineer or architect, and wisely separate these departments from that of contractor. Why should not the same principle obtain when we would construct a steamship, whose cost will perhaps amount to 50,000*l.*? Assuredly it is as requisite; for there is as as essential a difference between the naval architect or engineer, and the shipbuilder—between the skill which projects and adapts, and that of workmanlike perfection and business-like honesty, in the construction of steamvessels—as in the abovecited case; and it unfortunately happens, for want of this division of employments, that between what steamvessels *ought to be*, and what *they are*, in respect of security, there exists as great a difference as between the solidity of London bridge and that of a county job.

In steamvessels, the public are accustomed to look to speed and cabin attractions alone; and think no more of the strength or sufficiency of the hull, engines, and boilers, than people do of the walls of a theatre when they enter it. It is the business of the Government, or of the laws, to provide for the public security, and to meet the exigencies of the case. It is the real interest of steamvessel companies or proprietors to build substantial and thoroughly seaworthy ships, and to enlist the highest professional skill in their construction. This can only be secured by the separation of the duties above defined; and it will provide the best guarantee for the safety of the public, whose lives are now too often jeoparded by the cupidity or ignorance of owners or builders. In working out this desirable change, the labors of your commission cannot but be of advantage; as, if they do not at once provide a substantial remedy, they will open the eyes of the owners and the public, and ultimately lead to what is desirable and practicable.

I have, &c.,

C. W. WILLIAMS.

MARCH 30, 1839.

On iron water-tight bulkheads.—By C. W. Williams, Esq., Liverpool.

A desire to lessen or prevent those accidents to which ships are liable at sea, has long engaged the labors and attention of humane and scientific

men ; and, when we consider the fragile nature of a ship as compared with the tremendous force of the sea, and that a single plank is all that is interposed between that element and those on board, we are tempted to express our astonishment, not that so few vessels are lost, but that so many escape.

The casualties to which ships, particularly steamships, are liable, arise, for the most part, first, from striking against or coming in forcible contact with rocks, or such solid bodies as would injure the framework of the vessel ; and, secondly, from accidental collision with other vessels, by which some part of one or both vessels become so damaged as to admit the water to such an extent as to overcome the power of the crews to pump it out.

Ingenious men have endeavored to devise expedients for lessening the risk consequent on such damage. Among these was the introduction of air-tight tubes to such an extent as, in case the body of the vessel being filled with water, should give it so large a buoyant power as to keep the vessel afloat. A patent was obtained for this invention, and an ingenious tract published, demonstrating the protection which a given number of tubes, distributed throughout the vessel, would afford. It does not appear, however, that the practicability of stowing away a sufficient quantity of those tubes, or air-vessels, was ever tested in practice, or that a vessel of any magnitude was so fitted as to demonstrate its utility.

That any expedient shall be discovered which will prevent the irruption of the water to an extent beyond what may be within the power of men and pumps to expel, is a hopeless case. Even in the event of running on an anchor or other body which should break any part of the ship's bottom or side, or of a single plank starting, the extent of the injury would most likely be such as to render it impossible to keep the vessel afloat by human power. It occurred to me, that the only practicable expedient for preventing the sinking or actual submersion of the entire vessel would be, by confining the effect of the injury sustained to that portion or section of the vessel in which the injury occurred ; and this is the basis of the plan I am now to submit.

Hitherto, nothing has been attempted which could prevent the water, in case of its breaking in, from collision or other causes, from *passing at once throughout the entire body of the vessel ;* and here lies the great source of danger, particularly in steamvessels, as the fires, being at the lowest part of the hull, are soonest affected by the water ; and the chances of escape, by being expeditiously run on shore, are thus lost. Indeed, in steamvessels, the mere circumstance of derangement to any of those pipes, or connexions between the interior and exterior, for the necessary introduction and expulsion of water from the engine and boiler, have often caused the most serious results. In one instance, the casual introduction of a piece of seaweed under the valve of the bilge water-pump of a steamvessel, caused it to fill nearly to sinking. But when it is considered that those casualties, which too often end in the sinking of a steamer, are local in their origin, and affect but a small portion of the vessel, and that the water admitted is often of so small an extent as to be almost within the power of the pumps, it will at once suggest the importance and the efficiency of the protection, by confining the water to that section of the vessel which has sustained the injury.

The plan of dividing the vessel's hull into sections, each of which should be completely water-tight, has, we are told, been practised by the Chinese

in their trade-barges, the several water tight compartments being under lock and key, and appropriated to separate shippers.

This mode of giving security first occurred to me on building the iron steamer the "Garryowen" (now plying on the Shannon, at Limerick), and the trade-barges which the Dublin Company's steamers tow on that river. Where the hull was of iron, as in the "Garryowen," the introduction of iron plate bulkheads was easy and effective; and, independently of the great strength afforded by this internal and sectional bridging (as it may be called), these sections were as susceptible of being made water tight as the vessel itself.

Experience has proved that it is impossible to make a timber partition or bulkhead water-tight, or at least that it should continue so. The heat of the vessel is sufficient to cause such a shrinking in a partition of timber planking, as to render it wholly useless in preventing water from passing. Iron plate partitions, however, possess all the requisites for this effectual division of the vessel into so many water tight compartments. Their introduction into timber built ships appeared, then, an important desideratum. Many objections were, however, started. Men do not like to be put out of their way; and, indeed, a plan which should prevent ships foundering at sea was, at least, not likely to find much favor in the eyes of shipbuilders.

The only parts where water could pass from any one section, when filled, to another section not so filled, would be, not through the iron partitions, but at the sides and bottom of the vessel, where they came in connexion with the frame and planking of the vessel. The preventing the water from passing in this direction is effected by very simple means, viz: by making this part of the vessel solid, that is, without those rooms or spaces which intervene between the frames of the vessel. This solid framing should extend to 18 inches before and after each partition. The mode of effecting this is familiar to all shipbuilders. The introduction of hairfelt between this solid framing and the planking on the outside, and the ceiling on the inside, completes the operation; the plate iron forming the partition having proper diagonal stays to give it strength, and being connected at the sides and bottom with angle iron, accurately fitted to the shape of the vessel, particularly in passing over the kelsons.

The practicability of making these water tight iron bulkheads being established, the next consideration was the number that would be required and their most eligible position. A *primâ facie* view of the case would suggest the greatest possible number of divisions; certainly the more numerous the partitions are the more complete would be the protection afforded, and the more the risk of foundering diminished. The only considerations which restrict their number are, 1st, the inconvenience they create by preventing free access from one part of the vessel to the other under deck, the access to each being then, necessarily, from deck; 2d, the weight of these iron bulkheads, and the additional timber required to make the vessel solid at the place of junction; 3d, the expense.

In considering the number and situation of these bulkheads, I will examine the advantages and disadvantages of each.

Let us consider the case of a vessel of the largest class, say 160 feet long, divided by a single bulkhead into two equal divisions. It will not be necessary to dwell on the inefficiency of such a division. Any leak or break must inevitably cause the filling of one-half of the vessel. The result would be, that either the vessel would be in danger of going down end foremost, or

would be in such a position that it could not resist a heavy sea. At all events, in that situation the engine would be useless, as the boiler could not be worked with the water driven to one end.

Let us next consider the effect of placing two such bulkheads, and thus dividing the vessel into three equal or unequal sections. In some respects this would be a favorable arrangement, as any two sections would effectually keep the vessel afloat. The inconvenience of such a division is, that in case of a vessel being run foul of at the intersection of either partition, two-thirds of the vessel being possibly filled with water, the centre of gravity would be thrown so much to the one end as to render the vessel unsafe in case of a heavy sea.

Let us next consider the dividing the vessel into four sections by three bulkheads. This arrangement would answer all the ends of protection, but an insurmountable objection here presents itself. The machinery would then be divided, as one of the partitions, the centre one, would necessarily fall in somewhere between the engine and the boiler; and, considering the connecting tubes, and other circumstances which render a free union between the boiler and the engine departments absolutely essential, this arrangement is out of the question.

We come next to the division of the vessel into five sections, by means of four bulkheads. This arrangement I consider wholly unexceptionable. Besides, this division fell so well in with the business of the several parts of the vessel as to give it at once precedence. The centre section would then be occupied by the engine, boiler, and coal-bunkers, thus detaching them entirely from all other parts of the vessel. The sections Nos. 2 and 4, would be the fore and after holds, or, in case of passengers' vessels, the fore and after cabins; and the two remaining sections, at the bow and stern, need not be as high as the main-deck, as the water never could rise within several feet of the same.

Here, then, we provide an effectual remedy against the casualties attending on a vessel coming into collision with another. It may safely be said, that unless the water break into the vessel in all its sections at the same time (and which may be considered impossible), there can be no danger of submersion; and experience has proved, that a very small addition of buoyancy would prevent a vessel from sinking after it had been so immersed that the deck was on a level with the surface of the sea. Now, this improvement in the construction of steamers is not brought forward as an ingenious theory, or a matter of unascertained efficiency; I merely submit for general information, what in practice is adopted by the Dublin Company at this moment in all their lately constructed steamvessels, to give security to the public, and protect their own property from casualty or loss.

The model [furnished with partitions on the plan recommended] is illustrative of what may be seen in several of their vessels now at work, the "Garryowen," the "City of Limerick," the "Athlone," and the "Royal William," and also in five other vessels recently built by the Company, the "Royal Adelaide," the "Queen Victoria," the "Duchess of Kent," the "Prince," and the "Princess," now getting their engines on board.

For testing the efficiency of these bulkheads, and that I might assure the members of the British Association, when in Liverpool, of their having stood the necessary proof, and being practically as efficient as they were satisfactory in theory, I caused the plan to be experimentally tested in the new vessel, the "Royal Adelaide," for the inspection of the members of the

Association. I first caused this vessel to be bored, and the water to flow freely into section 1, at the bow end. When so filled that the water remained at the same level outside and inside the section, it depressed the vessel six inches at the bow, raising the stern about two inches. Having the water pumped out, I then had the next bow section filled (No. 2). This depressed the bow 12 inches, without perceptibly raising the stern end. The vessel was then in the situation of one in which collision had taken place. For accuracy's sake, I here state, that the bow and stern sections are each 16 feet long; the two next, 35 feet long each; and the centre, or engine section, 58 feet, making in the whole 160 feet.

The fact of buoyancy, then, not admitting of a doubt, the whole question of efficiency turns on the practicability of making those bulkheads water-tight; this, then, has been tested in so satisfactory a manner that I do not hesitate to affirm, that, had the "Apollo," the vessel run into and sunk by the "Monarch," on the Thames, or the Bristol packet the "Albion," run on the rocks in Jack's sound, near Milford, and many other steamvessels, been appointed with those water-tight iron partitions, no risk of life would have occurred, and the vessels would have remained afloat.

With respect to the additional weight and expense of these iron bulkheads, I would observe, that, compared with their importance and the security they afford, they are comparatively insignificant. The bulkheads on board the "Royal William" and the "Athlone" cost 290*l.* each vessel; and the additional timber required in the solid framing must be trifling.

Considering, then, how deeply the public are interested in the progress and improvement of steam navigation, and the rapid strides it is making in all parts of the world, and the multiplication of the risks of collision consequent on that increase, it cannot be doubted that it is a legitimate object for the interference of Parliament. Can any rational or humane mind contemplete the consequences of a collision between two vessels, and the loss of life that may ensue, and not admit that they who build a vessel hereafter and neglect such precautions, undertake a responsibility of the most awful nature? Had I the power, I would enforce this protection by law. All vessels, especially such as shall hereafter be built expressly for the conveyance of passengers, should have a license, granted on inspection and before registration, certifying the insertion of those or other equivalent preventives against sinking.

Having considered the protection afforded by these water-tight bulkheads in case of collision, I will now observe on the other and perhaps not less important advantage they afford, namely, as a protection against fire. In this case, the circumstance of any part of the vessel taking fire is followed by the same evil as in that of the irruption of water on collision, namely, its irresistible transmission at once through all parts of the vessel. An instance of this calamity occurred recently to the steamer the "Medway," on the river Thames, where the only resource that remained to the numerous passengers, was the confining themselves to that part of the deck most distant from the fire (and, fortunately, in that instance most favorable as to wind), until the vessel was run ashore. Now, the circumstance of these bulkheads being air-tight, as they necessarily are, is a matter of the greatest importance in preventing the spread of flames, as they effectually prevent the introduction of any draught or current of air, so much to be dreaded in such cases where the materials are so combustible. Again, in extinguishing the fire in the section in which it originated, the crew would be enabled to

work in comparative security. The fire, being prevented spreading laterally, can only make progress upward towards the deck, and which will be considerably retarded, if not altogether checked, by the absence of all current of air from either end of the vessel. Indeed, it is questionable whether the mere closing down the hatches over the section would not at once extinguish it.

I need only add, that vessels so appointed may, with great propriety, be called safety vessels. The plan is not restricted by any patent, and all are free to adopt it; and I expect hereafter to see this principle so adopted and improved, that the security of steamvessels will keep pace with that greater utility and extension to which they seem destined.

C. W. WILLIAMS.

Messrs. Wilson, Milcrest, and Russell, shipbuilders, Liverpool.

Mr. Thomas Wilson (of the firm of W. & T. Wilson), Mr. Milcrest, and Mr. Wilton Wood Russell, eminent shipbuilders in Liverpool, recapitulated several of the losses of steamvessels which had occurred within their knowledge. They attribute the loss of the "Erin," from London to Belfast, in great measure to her breadth of sponsins (or overhanging of the sides), a mode of construction not now practised by judicious builders. The "Rothsay Castle," lost near Beaumaris, was also too much overhung; had been built in the Clyde, and used originally as a river boat. They remarked, that no one acquainted with her state would have sailed in her; and it is too frequently the case that such vessels, after having run several years, are bought and used as seaboats on other stations, where their condition and insufficiency are unknown.

Collisions are frequent, many lives lost, and immense damage done to property and vessels of all kinds for want of a universal code of night-signals, and the observance of a general rule of the road. The custom at Liverpool is, in meeting, for each vessel to starboard her helm, and in London to port it. Hence arose the violent collision between the "Royal William" and "Tagus" steamers. The first received the greatest shock; but from being divided into water-tight compartments, though the forward one filled, she was saved. Messrs. W. & T. Wilson built and repaired her.

Fires have been frequent from the ignition of coals through carelessness, and several cases have occurred which are attributed to the spontaneous combustion of coals. This arises chiefly from the coal-bunkers or boxes not being swept clean often enough; coal dust gets into the bilge, and lies there in the damp and warmth till it takes fire.

The river steamers, in particular, are ill provided with efficient safety-valves, as they usually have but one, and that placed on deck accessible to the engine men and passengers, and loaded with weights without rule. They advise that all vessels (steamers) should be compelled to be supplied with two safety-valves, weighted in the inside, and so constructed that it should not be in the power of the engineer to put additional weight on them, when steam is up, but capable of being opened at pleasure for letting off the steam; also to have two common gauge-cocks and one glass water-gauge to each compartment of the boilers. By having two or more safety-valves, should one get gagged the other would let off the steam when above the proper pressure. The engine-men commonly, on starting from the pier-

head, load the valve unduly, in order to beat each other in speed, whence several accidents have arisen. These men not unfrequently sit on the weights to keep the steam from blowing off. An Ellesmere steamer blew up some years since in consequence of overloading the valve before starting, in order to race another vessel. The explosion took place as she was casting off, and many persons were killed.

Some of the companies (the City of Dublin and St. George's) adopt the inaccessible valve in sea-going steamers.

River steamers are also generally deficient in water and pressure gauges. The boilers of the "Victory" (small steamer) were burnt from being short of water, and a collapse of the exterior shell took place.

They expressed their opinion that public security would be greatly promoted by not permitting any engineer to act, without producing a sufficient certificate to his moral character and mechanical capacity (but no license to be exacted, as this would prevent really good men, though not regular mechanics, from being used, which now keeps men of higher pretensions in check), in which respects they are now too frequently deficient, especially in river boats.

Mr. John Laird, iron shipbuilder, Liverpool.

Mr. Laird stated, that he was in the habit of making and repairing a great many boilers for steamers; that he has seen them taken out of vessels in so worn a state that the hand could be pushed through them, consisting of little else than scales and rust; that the back flues were never much worn, the outside shell being generally the worst, particularly towards the bottom, which has been kept tight by the dirt and deposite, and about the top and steam-chest, from the deck water and spray corroding them; that the duration of an iron boiler may be called four years, it being useless to repair them after that term. Copper ones will last ten years, and he knew one now in use made in 1824. He put a new boiler into the "Rothsay Castle" a week previous to her loss, which he attributes to the defective state of her hull, not to the machinery. Knew of a case of spontaneous combustion of coals occurring in the Thames, on board the "Rainbow" iron steamer, of his construction, and which plies between London and Hamburg.

Mr. Laird has since communicated to us the following:

FEBRUARY 22, 1839.

GENTLEMEN: In compliance with your request, I send you enclosed memoranda about iron steamers, and have no doubt a perusal of them will satisfy you they possess many important advantages.

I had letters (last month), containing the following particulars respecting the "L'Egyptienne," a vessel built for the pacha of Egypt in 1837:

The pacha wished to take her up the cataracts, and had passed all but one; her engine (45-horse) was found insufficient to drive her over that, and to force her up; he had ropes made fast to each bow, and about 200 men on each side the river to endeavor to haul her up; the rope on one side broke, and the consequence was, she was driven with great violence on the rocks; a hole stove in her bow, between stem and foremast bulkhead; her rudder knocked off, and one paddle-wheel very much damaged. As

soon as they repaired the rudder and wheel, they steamed her down to Alexandria, docked her, riveted a patch on the hole, and found her bottom otherwise in excellent order, the injury not extending beyond the fracture I have described. Had she not been fitted with bulkheads, she would most probably never have got off; certainly not without considerable delay and expense.

A large vessel (120 feet long, 26 feet beam) which I built for America, in 1836, has also been severely tried: she was driven ashore in a gale, and, on the water leaving her, was found lying across the trunk of a large tree. She was got off in a few days, the iron part of the hull uninjured; and as soon as the repairs to her woodwork (paddle-boxes, rims, bulwarks, &c.) had been completed, she again resumed her station, and, by the last accounts I had of her a short time ago, was in as good order as the day she was launched (in May, 1836). Had she not been an iron vessel, the owners were quite of opinion she would have been so damaged as to be rendered totally unfit to repair.

I could adduce many further proofs, and shall be glad to do so if you think it worth while.

I can only add, that I have built, and am building, more than thirty iron steamvessels, most of them of large size, and that of those at work not one has started a rivet, or proved defective in any way; and, from the experience I have had, I have no doubt that the vessels now in progress will be more complete than any alluded to in this or the enclosed letters.

I have, &c.

JOHN LAIRD.

Capt. J. W. PRINGLE and JOSIAH PARKES, Esq.

Messrs. Fawcett & Preston, engineers, Liverpool.

Mr. Fawcett stated that, besides those for large sea-going steamers, they have constructed engines for many of the ferry-boats, and always apply two safety-valves; one placed in such a position as to be inaccessible to the engineer, and loaded only to the usual pressure for such boilers, viz: four pounds to the square inch.

That he has sometimes known these to have been afterward altered by some blacksmith, so as to give the engineer power to load them as he pleased, and believes they have often done so to twenty pounds to the inch; in fact they do not know themselves what weight they put on, or what they are about. This great pressure is added when they are *firing up* to leave the quays, and when racing other vessels.

Mr. Byrom, engineer and foreman.

Mr. Byrom confirmed generally what had been stated by Mr. Fawcett, and particularly as to the alterations made in the loading of valves by engine-drivers, and that boilers not calculated to stand above six pounds per square inch, were often worked to ten pounds, and more. He considers that boilers should be made quite distinct, particularly for sea-going vessels, in case of any accident occurring to them when at sea.

That the engineers are generally a drunken, and often an ignorant set, particularly in small steamers, such as ferry-boats. That it would be of advantage, that they were compelled to pass an examination as to their capability, and to give securities for good conduct.

That steam and water gauges should be required to be placed in all steamvessels, and the boilers should be blown off every four hours, about eight inches of water at each time.

The "Garryowen," an iron steamboat, built by Mr. John Laird, of North Birkenhead, has been employed upon the river Shannon, since November, 1834. During this period she has been twice driven on shore, with great violence, by storms, and the following are extracts from the reports of those circumstances made by her commander and engineer:

Captain Bingham, of the "Garryowen," dated Limerick, June 16, 1838.

"With respect to the 'Garryowen,' I am very glad to be able to tell you she looks as well, if not better, than she did when she came to the Shannon; as to her strength, we had a very good trial; we broke adrift in a gale of wind from the pierhead at Kilrush, last winter, and got ashore at low water upon a very dangerous rocky point, and beat over it for two hours, the sea running very high, having 450 large pigs on deck. I do assure you, if she had been built of timber and struck so heavy, and did not go to pieces, she would certainly have been ruined; and the 'Garryowen' did not suffer the least injury, with the exception of a very small dinge on the turn of her bilge on the starboard side; there is not the least sign of corrosion or rust to be seen. I keep her well coated, both inside and out; she goes very fast, is a great favorite with the public, and has done an immensity of work; we ran her every day last winter, and always made the passage; she is as tight as a bottle, and never made a drop of water."

From Captain Bingham, dated Kilrush, January 20, 1839, *referring to the hurricane of the* 6*th instant.*

"We went ashore about two cables' length to eastward of the pier, and struck very heavy for the first hour; the ground under our weather-bilge was rather soft clay, covered with shingle and loose stones, some of them pretty large; under our inside or lee-bilge the ground was very hard, being a foot-path at low water, and many loose stones scattered along it. I was greatly afraid she would be very much injured by it in her bottom, but I am very happy to tell you she has not received the least injury; in fact, her bottom is as perfect and as good as the day she left Liverpool; not a single rivet started, nor a rivet-head flown off. If an oak-built vessel, with the cargo I had on deck, was to go on shore where the 'Garryowen' did, and get such a hammering from a heavy sea, they would have a different story to tell."

From Joseph Parry, Engineer of the "Garryowen," dated January 19, 1839, *referring also to the gale of the* 6*th instant.*

"We found, while trying to get the vessel off, she would not fall into her dock, although we cleared away the bank (which is composed of clay and

shingle stone) within a plate and a half of her keel; she would not move even then at high water; so we cleared away the bank above 40 feet aft and 30 feet forward, leaving nothing to bear her up forward or aft but the strength of the vessel; and, although there was such a distance and length of overhang, yet there is not a rivet started or seam open, nor least injury received whatever. Out of twenty-seven vessels that got ashore that night, the 'Garryowen' is the only one that is not damaged more or less."

Captain Henry Mangles Denham, R. N., F. R. S., and Consulting Marine Surveyor, Liverpool, &c.

March 14, 1839.

Gentlemen: 1 and 4. I am not prepared to give dates and names, but in my four years' operations as marine surveyor to the port of Liverpool, I have known instances of steamvessels leaving the docks and foundering (without stress of weather) in a few hours. In one case, so recent as December 29th last, a steamer sunk from under my own foot six hours after being hired, without any interruption of machinery, but from leakage beyond the pumping powers, particularly after the water reached the fires and stopped the engine-pumps. I consider steamers (small jobbing ones particularly) to be neglected by the masters and crews respecting hull-seaworthiness, in proportion as they habitually neglect all the usual or stand-by equipments which seamen in sailing-vessels look to; they indolently, and often vexatiously, repose on the engine as if infallible. In fact I have seen a binnacle capsize half a dozen times; and the small stock of water wasted by the skuttle-casks fetching way before they could persuade themselves that a lashing was necessary. And it appears to me, that as men are required to know little more than merely steering, they belong to a class so unlike regular seamen, that so long as the vessel will go at all, and does not make water beyond what the engine-pumps can keep under, they think it no crime to conceal from the owners the having been beating on a shoal, or been subject to a violent concussion. A case occurs to me: on my reporting that a steamer had sunk under circumstances quite unaccountable, the owner said, "Oh, sir, it comes out that she was on shore the other day, and broke her keel."

5. I have reason to believe, that rather than lie by for a day, steamvessels are exposed to the risks of sudden break-downs. It is a rare thing to hear of engine or boiler defects being anticipated; such are generally announced by engine or boiler after under weigh. These remarks apply especially to river or jobbing steamers. The coasting or voyage steamers have loading-days at least, which give the engineer a chance.

7. No mercantile steamer carries an adequate number of right sort of boats. And as to river or short coasting trip steamers, they are frequently without a boat at all, or have such a one as would not swim, or are without gear for her; while, as to sails, cordage, leadlines, compasses, lanterns, adequate ground-tackle or number of hands, they are miserably and disgracefully deficient. And yet river-boats undertake to tow ships out of port, and risk being benighted with inward-bound passengers, mails, and vessels. The steam ferry-boats on the Mersey have been actually four hours in a fog in trying to cross the river not a mile wide, so unprepared and ignorant are they for any thing out of the usual course.

8. No general system of lights exists at Liverpool; some carry three lights, one at foremast-head, and one at the fore part of each paddle-box. Some carry the upper light at the fore part of the vessel; some carry a red light on starboard paddle-box, and a plain light at the opposite paddle box and mast-head; some carry lights on their quarters; some a middle light at the bowsprit end. All, however, attend to one rule, and that is, in passing each other on their starboard sides; but I understand the reverse is observed at other ports, which has naturally been attended with collision when a Liverpool vessel gets among them. Now it is to be wished that a compulsory general rule were introduced; and I submit that three plain lights, one on the foremast-head, and one on the fore part of each paddle-box (not to throw any light abaft the beam), cannot fail to indicate the position of the vessel. And as it is most important to know when the rule should be departed from (as in the case of two steamers suddenly discovering each other in rounding a point of land, or closing in a fog), I propose that the starboard paddle-box-light should be masked, so as to cross the line-of-keel direction at an angle of 17 degrees towards the larboard-bow. It would then be simply thus: If you ever perceive the three lights of a steamer (which must be in a vertical triangle, if seen at all) on your larboard bow, then you must starboard your helms, and cross to the right side, until respectively on the starboard bow of each other. If, however, you do not see the three lights, it is certain you have so advanced on each other's forward track as to have shut in the starboard light; and if you attempt to recover the right side by crossing, you will, in all probability, run into each other. It is then that the rule should be abandoned, and each vessel keep her previous course. I annex a diagram to explain my plan, and have assumed the starboard side as the rule side. The plan will apply conversely. In the case of other craft and steamers, I can only suggest that while the steamer must in all cases give way (or stop, if risking a shoal), yet it should be imperative that the sailing vessel show a light over her quarter towards the approaching steamer; of course the showing the lantern in time depends on the look-out on board sailing-vessels: a fixed light on each quarter of sailing-vessels would be well when in pilot-waters. This is a point not at all settled as regards Liverpool. Vessels at anchor, however, are expected to keep a light up at the fore-stay.

9. I believe the accidents from fire to take place chiefly from the proximity of the boilers to the ceiling or inner planking of the vessel's sides, the small space between being often filled up with firewood, blocks of coal, &c., which ignite when the water supply of the boiler is neglected, and the boiler becomes red-hot; *as I have seen it*. There is another cause of fire arising from the proverbial neglect of small and jobbing steamers, viz: the extra heat produced under the deck, where the funnel unites with the flues, when, for lack of cleaning, the soot is burning out. The deck and nearest beams are generally reduced to a sort of touch-wood by the inordinary heat from time to time, and in the neglectful cases those timbers are too ready for ignition. I know the coal-bunkers are generally in contact with the boilers, which is an inexcusable plan. Neither the bunkers nor the coal-hold are cleared out so often as they should be. I do not attribute to spontaneous ignition all the accidents so ascribed; such may be often alleged to cover a palpable neglect elsewhere. I, therefore, would impose the frequent clearing out, on wholesome grounds, and to shut out the argument of spontaneous ignition, when investigating fire accidents. I

believe that, to avert those accidents, it should be imperative on the owners to dedicate more space in the outset to the boiler and coal region; and, to counteract the appearance of unavoidable or neglectfully-caused fire, a proper number of hoses, deck-plugs and scuttles over the boilers and bunkers should be fitted; such hoses to have combined means of playing by hand-labor as well as engine, for it will happen that the engine-room has to be abandoned in case of fire.

10. I would suggest that all steamvessels, from the smallest to the largest, be under permanent regular rules and establishment, subject to accredited inspection and certification on clearing out from custom-house to custom house; or, if river navigation, a suspension of register and fine for non-compliance. That the master and mate should not only have served in those capacities in sailing-vessels of corresponding tonnage, but go through an examination as to the common working of the engines; for it is a fact, and a frightful one, that in nine cases out of ten the whole mass of life and property entirely depends on the existence, health, sobriety, or indeed honesty of purpose of *one* man, *the engineer!* There should always be a second-class additional engineer when the vessel exceeds 100-horse power; and the fire-stokers should be one for every 25 horse power. The seamen should be in the proportion of one to every 30 tons, carpenter's measurement, exclusive of mates. Each vessel should be so masted and rigged as to ensure her working under canvass, and a double set of sails, as well as spare cordage, should be carried in her. Also fresh water, at least one gallon per person per day; also spare binnacle and compasses, and boats in proportion, of 25 feet, for every 100 tons up to 500 tons, and 20 feet to every 100 tons above 500 tons; *i. e.*, a vessel of 500 tons would have 125 feet of boat keel; and a vessel of 1,000 tons 200 feet of boat-keel; none of her boats to be of less beam than one-fourth the length; and each boat to be equipped with oars, masts, and sails, and boat binnacle. I would also suggest that each steamvessel carry as much duplicate machinery as possible, even to cranks, cross-heads and beams; and, moreover, as respects river steamers (to which all the foregoing applies in proportion to the tonnage), I would require that those of single engine, or having false deck-breadths upon sponsins, be not registered for going outside the high-water confines of the river or harbor, as the cross sea of the offing constantly endangers such construction of engine or vessel.

The ground-tackle of all steamers is generally too light. I would oblige them to carry anchors and cables of one-fourth less than sailing-vessels of same tonnage; for instance, a ship of 500 tons has anchors of 26 cwt., and chains of $1\frac{5}{8}$ iron. A steamer of same tonnage (including engine-room in the measurement) should not have less than 20 cwt. anchors, and $1\frac{3}{8}$ chains. And with reference to chains, a certificate of price, as well as from proving-machine, should be exacted. On this subject it will be excused, if irrelative, if I remark, that the mode of testing chains at Liverpool, viz: by gradual tension to a given leverage, by no means proves bad workmanship or bad iron. I have known chains to break within one ton of the 40 tons required, a new link put in, and some other link break before the chain comes up to three-fourths of the first strain borne one hour before; by which it appears to me that a chain may carry the proof, as it is considered, while elongation exists in the links; but that the power of elongation being exhausted, it will snap at one-half the former strain if tried again: thus a ship has a *broken-hearted* chain, and the testing-machine broke that heart.

I would rather confide to the effects of a jerk from a falling weight, and a strict examination of each link. Above all, the price given should be such as to ensure good workmanship. I cannot refrain from quoting a passage in a letter addressed to me by the commander of one of the New York line of packet-ships, in reference to the light-ship of Liverpool bay breaking adrift last January: "*The Trinity Board pays 21s. per cwt. for their chains, the Dock Committee of Liverpool, 16s. per cwt.; in the former case the iron is of the best quality, and every link made with the greatest care; in the latter the iron must be inferior, and the chains made just sufficient to bear the test.*"

Reverting to steamvessel fitments and equipments. Voyaging and coasting steamers should be obliged to carry a medicine chest, if not a surgeon. Each vessel should be prepared to stow a due proportion of fuel according to her scale of consumption and plying distances; and the number of hand-pumps should be increased; indeed the number of signal-lanterns should be defined, with a proportion of blue-lights and rockets for particular cases; also a supply of Carte's rocket-lines, to produce a line of communication if stranded.

I am, &c.,

H. M. DENHAM, *Captain, R. N.*

Capt. J. W. PRINGLE and JOSIAH PARKES, Esq.

Lieutenant George Crichton, R. N.

"An erroneous idea is prevalent among naval officers, that merchant steamers cannot be made applicable to warlike purposes, and that neither their sides nor decks are calculated to bear the pressure and weight of tiers of guns; but the revolution which must take place in naval tactics, in the event of war, by the extensive use of steam-power, will overturn all such trivial objections.

"The chief armament of a steamvessel will consist, not of broadside guns, but of bow guns, increasing in caliber but not in number, according to her size; and when it is considered that there are above sixty merchant steamers capable of mounting guns which would at each round throw a weight of shot equal to the broadside of a 42-gun frigate, and that there are hundreds of other steamvessels from which a much more destructive fire could thus be directed than from any of our sloops of war; it may safely be assumed, that in six months from the declaration of hostilities, all sailing-vessels under the size of the heavier class of frigates which are fit to take their station in the line of battle, will cease to be an effective part of our navy, and each ship of the line will require to have a steamvessel attached to her.

"With this view, it will be the object of owners of steamvessels to comply with any reasonable regulations as to their equipment which may qualify them for Government employment; on the other hand, it will become of more public importance that the persons engaged in the conducting such vessels shall be possessed of superior acquirements to those now generally expected from persons in those situations; and a specified apprenticeship, and subsequent examination, for masters, mates, and engineers, seem to be indispensable; for though naval officers may be appointed to command and attend to the gunnery and other fighting departments of such armed

steamvessels, hired on any emergency, the present masters and crews of such vessels who have been constantly trained to the conducting them through intricate channels, and narrow rivers crowded with shipping, would, with proper preliminary education, be by far the most expert in the quick manœuvring and other peculiar management of steamvessels.

"Great Britain has thus, from its extensive commerce and seacoasts, the means of defence in a great measure provided by its mercantile steam-navy, and the amelioration of the condition of the seamen employed therein, has become an object of far greater importance than ever."

William Bain, Esq., R. N.

"GENTLEMEN: I have commanded first-class steamships without intermission from the year 1820 till May 1838, on the London and Edinburg station; and, during that long period of active and laborious service, devoted much attention to the improvement of steam navigation."

"5. Is of opinion, with a few exceptions, neither engines nor boilers are examined or repaired so frequently as they ought to be, or kept in that cleanly and orderly condition so conducive towards the interests of the owners, or desirable and satisfactory to passengers; in consequence, the boilers become so coated with filth and dirt as render inspection difficult to detect defects; thus, vessels are often sent to sea in a dangerous state, the first knowledge of which is the sudden and alarming escape of steam, and, of course, the destruction of steam-power. Has frequently had occasion, and has witnessed it in other ships, sometimes under very trying circumstances, to stop rents in boilers by temporary expedients, and have seen boilers worked till they were as thin as paper. Boilers ought to be allowed to remain no longer in steamvessels than three years, or, with the utmost care, four years, without a thorough repair.

"6. The safety-valves in the Scottish boats, and in others frequenting the Thames, are usually left open and exposed to be loaded by engineers and strangers, as whim or caprice may dictate. They should be enclosed and rendered inaccessible while the steam is up. That four brass blow-off cocks, three and a half or four inch, should be permanently attached, two forward and two aft, to the bottom of all sea-going boilers, two of which ought to be opened alternately every two hours. That glass water-gauges should be fixed on the face of all boilers, to indicate the height of the water. That many vessels are without these simple instruments, and the engineer and firemen, when doubtful of the accuracy of the cocks, try to ascertain this fact by hitting the boiler with a stick or hammer; and that no vessel should be permitted to ply without a mercurial gauge to denote the actual pressure of steam."

"9. Have witnessed many instances of coal taking fire spontaneously, in consequence of its having been in contact with the boilers. Great care should be observed in the formation of the coal-boxes to preserve a space, at least four inches, for a free circulation of air between them and the sides of the boilers; the deck, too, ought never to be less than one foot or 18 inches from the top of the boiler; the 'Medway' was burnt owing to this defect."

"10. Have never yet seen engineers or firemen possessed of that knowledge, good conduct, and moral behavior, which are so essential to the safe and economical working of the engines and boilers under their charge and

management. Owners, from a contracted and ill-judged system of economy, scarcely give adequate wages to induce men of a higher grade to become marine engineers. All engineers and firemen, therefore, should undergo a strict examination touching their fitness, sobriety, and moral conduct and character, testified by certificate, before permitted to fill situations so very responsible; for on them often depend the lives and property of all on board. Have ever considered this point of great public importance; and, with a view of forming a school to provide respectable marine engineers, and to raise them in their own opinion and in that of the public, have frequently suggested the propriety of engineers having an apprentice, of respectable parents and character, with a small premium, payable to the engineer at the termination of his servitude, to learn his business practically; that such apprentice should have served one-half of his time in a respectable mechanical shop, and the other half with his marine master, and to have his name entered on the owners and inspector's books, together with his character and conduct, that he may be provided for accordingly. During the abovementioned voyage to Gibraltar, I had often to lament the deficiency of practical knowledge and good conduct of my engineer. The ship, dismantled and laid up for the winter, was brought forward hurriedly, when this fellow of an engineer, who produced to the owners a good certificate, was appointed, with the very liberal salary of 12*l.* per month. His ignorance brought me into many scrapes, and was the cause of much delay."

Mr. Walter Paton, surveyor to Lloyd's, Leith.

"5. The engines and boilers are most certainly not overhauled frequently enough. For example, the Fife county ferry boats having only two on the station, and three ferries to supply, they can only spare each the alternate Sabbath for any repairs they may require; one having to supply the passage during the Sabbath.

"6. Am of opinion that all boilers should have at least one inaccessible locked-up safety-valve. Have seen the valve of a steamer on the Clyde fastened down by blocking the lever with a piece of coal. On expressing surprise at the same to the engineer, he seemed quite ignorant, but said there was no fear, as his boiler never made too much steam!!

"7. In boats decidedly deficient, the Frith of Forth steamers have sometimes from 100 to 150 passengers on board, with only one boat which would carry with safety not exceeding 15 or 20 persons. The sea-going steamers usually carry two quarter and one stern-boat, but I do not approve of their construction. They are generally of the same description as a man-of-war's cutters. They ought to be yawls, similar to the fishing-boats used here, which would carry more passengers with safety, and are also the best fitted for pulling off to the ship again through a heavy sea, for the preservation of the remaining crew and passengers, from their being much better sea-boats.

"In the case of the 'Benlomond,' a steamer plying between Newhaven and Stirling, in 1836, shortly after leaving the chain-pier she took fire; the passengers and crew were saved by another steamer which happened to come near, otherwise the loss of life might have been great from want of boats.

"The planking of the river steamers I consider too slight, being in some cases not above one inch.

"It would be very useful that steamers, particularly sea going vessels, could quickly disengage the paddle wheels, so that when brought under canvass, in the event of the machinery going wrong, the wheels might revolve and not impede the ship; and also if all sea going steamers were obliged to carry a heavy sheet-anchor, and a longer chain and larger size than is now done, great security would be obtained in event of accidents to the machinery from the vessel being enabled thereby to bring up in deep water in case of need."

"13. During the building no inconvenience can take place from survey.

"The first survey for classification would require the vessel to be put into a dry dock, or laid on the hard, for examination of the bottom. Afterward the periodical surveys would cause no delay, as each survey of hull, engines, &c., could be accomplished while the vessel was in port.

"Am of opinion that a survey twice in the year, as laid down by Lloyd's, or, say once in three months, with means of enforcing the repairs found necessary by the surveyors when pointed out, would prevent most of the accidents that occur. My employment as a special surveyor for Lloyd's, requires my whole and undivided attention to be devoted to the service of the society, and the limits of my district extend from Berwick on the south, to Fifeness on the north side, taking in the whole Frith of Forth. On special surveys I am called to the north coast, Dundee, &c., and also to Greenock, Glasgow, &c., for restoration and continuation of ships.

"I apprehend there would be no difficulty in procuring competent and honest engineers to survey and report upon the machinery and boilers, in conjunction with the surveyors appointed by Lloyd's."

John Scott Russell, Esq., F. R. S., Edinburg, Vice President of the Society of Arts of Scotland.

GENTLEMEN: I now send you some replies to the queries you have proposed to me. I have confined myself to such cases as I have had the means of personally knowing. I have witnessed several boiler explosions, and have made many experiments on the subject upon a large scale, and I have endeavored to give the results as concisely and practically as I can. The suggestions I have given, as to remedies and precautions, are such as I have the means of knowing to be practicable and efficient, either from their being already used partially with perfect success, or from their being such as I have found would be willingly adopted, and easily carried into effect by engineers and other practical men employed; a great number of whom I have consulted, and whom I have had ample opportunities of conversing with, from the circumstance of having been appointed by the British Association to conduct some inquiries regarding the present state of steam navigation in Scotland. I have avoided submitting to you any considerations of a hypothetical or crude description; and I remain perfectly confident that the bill for the preservation of the public safety will be one which will effectually secure that important subject of legislation without trammelling the inventions of genius, or repressing the spirit of mercantile enterprise. I have, &c.,

JOHN SCOTT RUSSELL.

1. The case of the explosion of the "Earl Grey" steamboat came particularly under my notice; as I examined the boiler before the accident and after it, and was consulted by the sufferers as to the propriety of their prosecuting for damages. The following statement may be considered curious, and will show that in this case an authorized inspection would have prevented that melancholy event. It happened that I had gone to Glasgow some weeks before that accident, and was walking along the Broomielaw pier, examining, as I was in the habit of doing, every thing connected with the machinery of steamboats that came in my way. A young man who also took an interest in these matters was along with me, a Mr. Mitchell, of Glasgow. At one place I observed one boiler being taken out of a vessel, and another lying on the pier about to replace it: the vessel was the "Earl Grey." I examined both carefully, and directing his attention particularly to the new boiler, I said to him, what subsequent events impressed indelibly on our memories: "Look at that boiler; I know, from the practice of the parties connected with the vessel, that that boiler will be subjected to a high pressure, and, take my word for it, the boiler will certainly burst." This conversation might have been forgotten; but it happened that this young man's mother was on board of the "Earl Grey" when the accident occurred, and was one of the sufferers. This is surely a case where inspection would have prevented the accident.

My reasons for the opinion I formed were simply these: I knew that the parties connected with that vessel were in the habit of using pretty strong steam. I was of opinion that the boiler was not a very good one for raising a large supply of steam, and therefore that there would be an inducement to collect steam, and raise it to as high a pressure as possible at starting; and the boiler was of a form that required strong internal stays, and was nevertheless very defective in these, as there were few, if any. The consequence was, that the boiler exploded exactly as it ought to have done, the large tabular roof opening up like the lid of a chest.

The boiler was somewhat of the shape given above, and the explosion lifted up the upper part of the shell from the other in one mass. No accidental cause was required for this explosion, nor any very extraordinary pressure of steam. The large surface without stays was certain to produce the effect, even with such pressure as may be used in boilers (with perfect security) which have their stays properly arranged.

Another instance, of which I happen to know the particulars, is the explosion of the "Union," two years ago, at Hull. I have frequently seen danger incurred in the same way. It is well known that the pump which feeds the boiler with water only acts when the engine and vessel are in motion. Now, if the vessel be at rest, and detained by accident beyond the time of starting, the steam blowing off at the safety-valve, and the water being rapidly carried off, the water gets too low, the flues are uncovered and become red-hot, and thus, when the time of starting does occur, the motion of the vessel and the action of the pump raise the water on the red-hot metal, and steam is generated so rapidly that an explosion almost inevitably ensues. This was exactly the case at Hull. I have seen similar cases in which explosion was prevented by putting out the fire, and then pumping water into the boiler by the hand-pump.

4. I have the best means of knowing that the "Northern Yacht" steamboat was one of the very worst description of hull that ever issued from any dock-yard. She had on one occasion before been towed home in utter

helplessness. An authorized inspection of that vessel before being put to sea, would, probably, have prevented her from ever being permitted to ply, except inland, where she could not be exposed to a heavy sea.

The high reputation which the Clyde so justly enjoys for the sufficient and satisfactory qualities of her steamvessels, has necessarily raised up some individuals less scrupulous than others, who trade upon the reputation of the Clyde, and construct inferior vessels, so as not only to endanger the public safety, but to bring obloquy upon the many honorable and conscientious individuals on that river, who will not undertake to build any vessel of an inferior description or price. To such persons, as well as to the public, a proper system of steam-surveying would be of the highest consequence.

6. Of explosions, there are two principal causes: the one due to original construction, the other to subsequent mismanagement.

(1). Errors of original construction. Of marine boilers, there are two classes: tabular and tubular.

The tabular boiler is that in which extensive flat surfaces, or surfaces nearly flat, are used to form both the outward shell and the internal flues. This kind of boiler is that most commonly used by Bolton & Watt, by Napier, of Glasgow, and Caird & Co., of Greenock, and in general for all low-pressure boilers. Now, almost the whole strength of this depends on internal stays; with stays too small in number it is capable of withstanding very little more than $2\frac{1}{2}$ or 3 lbs. on the inch; but if by accident, or by overheating the flues, a greater quantity of steam should suddenly be generated, they are sure to give way, as in the Hull case and the "Earl Grey."

The only means of perfect security in tabular boilers is a regular system of stays. These ought to be distributed uniformly over all the surface in three directions—lengthwise, up and down, and transversely. This is at present done in the best boilers, but by no means universally.*

It should be a rule for tabular boilers that no portion of the surface, either external or internal, shall be left of greater extent than two feet square, without a stay sufficient to sustain the whole pressure on that surface.

It ought also to be enacted, that the water-space between flues shall no where be less than four inches thick for salt water, and three inches for fresh water.

Tubular boilers are frequently used, especially where considerable pressure is to be employed. In these boilers the flues and fireplace are generally cylindrical, and sometimes also the outside. The boiler of the "Victoria," which exploded on the Thames, was of this kind, only of an oval form.

In my opinion, internal tubular or cylindric flues of any considerable size ought to be employed only with extreme caution. They are liable to dangers which do not appear to be known. My attention was first called to them about twelve years ago by the collapse of a cylindric flue in a tubular boiler of my own, used for experimental purposes. This flue, on one occasion, when subjected to a moderate pressure, collapsed in the following

*I have seen tabular boilers under one-eighth of an inch thick, with stays at three inches apart, proved by steam to 120 lbs., and wrought at 60 lbs. in a steamboat. Locomotives are stayed at distances of four inches apart.

manner: the form of the flue inverting itself, and becoming convex instead of concave. After, however, it took this form, it stood very well, and sustained greater pressures than those which had caused the collapse with perfect safety. The boiler was of copper; had it been made of iron, an explosion would have taken place.

This directed my attention to the defects of circular internal flues, and I am satisfied that they should never be made of a large size for the purposes of steam navigation, as they were in the case of the "Victoria" explosion.

An internal flue answers very well, so long as every thing about the boiler is uniform and the heat equally diffused; but the moment that one part of the flue is made a little hotter than another, or has become thinner by use, or if there happens to be a bad plate of iron in the flue, from that instant the boiler has become dangerous, and has a tendency to invert itself and become concave as in the diagram.

It should be enacted, that no internal flue of the cylindrical form, and of more than two feet diameter, should ever be inserted in a marine boiler, and that its thickness should not be less than one quarter of an inch for six inches diameter, and one-eighth of an inch additional thickness for every additional six inches diameter, thus:

For	6 inches	diameter,	$\frac{1}{4}$ inch thick.
"	12	"	$\frac{3}{8}$ "
"	18	"	$\frac{1}{2}$ "
"	24	"	$\frac{5}{8}$ "

Of the external cylindric portions of boilers where the pressure is from the inside, outwardly there is no risk in a like degree.

In the original construction of the boilers, proper arrangements for a lock-up safety-valve ought certainly to be made, and there ought to be another safety-valve under the immediate command of the captain or engineers. But I do not think that even the common safety-valve should be accessible from without. There is a very simple arrangement sometimes adopted, in which the weights on the safety-valve are hung within the boiler, and the valve is quite inaccessible; but by a handle within, the engineer can raise the weight from the safety-valve, while at the same time he has it not in his power to make any addition to that weight. If this plan were adopted, even without a lock-up safety-valve, all danger from overloading would be removed.

The area of each safety-valve should be one square inch for every horse-power at least.

(2). Of errors of management, the greater part arise from the ignorance or intemperance of those who have the superintendence of the marine engines. It unfortunately happens too often that, for the paltry saving of a few shillings a week, owners of steamvessels give the engines and boilers in charge to ignorant, inexperienced, or intemperate men, who know little more than how to set the engine in motion and how to stop it. These men go on well enough while nothing extraordinary occurs, but in any emergency they become confused, and, having reached the limits of their scanty experience, have no further resources of skill or knowledge to draw upon.

I know no other cure for this crying evil than to issue licenses for qualified engineers.

Let a small board of scientific and practical men be appointed in each of the three kingdoms. Let any engineer who desires to have charge of a

steamboat and of British lives produce certificates of his steadiness, experience and sobriety, and let him be examined on his knowledge, both of the principles and practice of his duties, and then let him receive his license as first or second engineer. After having practised successfully for three years as a second marine engineer, he may pass his examination for first engineer.

All owners of vessels not having a licensed first and second engineer, should be liable, to the utmost, for all damage of every kind occurring to goods and passengers in that vessel.

Of safety apparatus.

1. Two or more *safety-valves*, as already mentioned, one or both placed under lock and key, so as to be inaccessible for the purpose of increasing the pressure, but having a communication so as to diminish the pressure at the will of the engineer; each safety-valve to have an inch of area for each horse-power.

2. A *mercurial gauge* should be attached to each boiler for the purpose of indicating the true amount of pressure at all times; as the common safety-valve only indicates that pressure when it reaches the maximum point. This instrument must, however, be used with a regulating stop-cock, that the motion of the vessel may not derange it. In practice it will be found useful to alter its usual form. Each leg of the siphon should have a spherical cup attached to it large enough to hold all the mercury in the gauge, in order to save it in two cases, when otherwise it would be lost and the instrument deranged. The higher cup will contain the mercury when by excess of pressure the steam shall have forced it out of the pipe, and the lower cup will contain the mercury when by cooling down the boilers a vacuum has formed within, in which case the mercury would otherwise be forced up into the boiler. The mercurial gauge should be an indispensable appendage to every boiler.

3. An *atmospheric valve* should be appended to every marine boiler. Many cases of collapse have occurred from working below the atmosphere, or cooling down the boilers entirely so as to create a vacuum within; but, independently of the immediate danger of explosion from this cause, a boiler is much injured by being exposed alternately to strains in opposite directions. This the atmospheric valve prevents. The best form of atmospheric valve I have seen is one applied under the supervisorship of Her Majesty's officers in distilleries. The spring which sustains the valve is made of a spherical form, and thus allows a wide range of motion, and the whole is contained in a case to protect it from injury, the case being, of course, perforated round the sides.

4. I propose that a very simple expedient shall be adopted both for the prevention of explosions and for the purpose of extinguishing fires. It is well known that a great number of injuries done to boilers arise in the following manner: The water is accidentally allowed to become low in the boilers, the flues get red hot, and there are only two remedies generally adopted; first, to rush in cold water into the boiler, which is the most erroneous and dangerous course; and, secondly, to draw the fire, which, although troublesome and dangerous to the engineer, is, nevertheless, safest for the boiler and passengers; although this method is very unwillingly resorted to, as it has the effect of exposing to notice the negligence of the en-

gineer, and may interfere considerably with the progress of the vessel. To remedy these evils and provide against this danger, I propose that a plan should be generally introduced which I have used, in a steamboat under my control, with great advantage. A pipe is brought through the side of the vessel to the boiler room, or is placed in connexion with the water without at the blow-off pipe, or the rose which admits injection water; this pipe has a leathern pipe connected to it, equal at least in length to the breadth of the vessel; a mouth piece is added like that of a common fire-engine, and the whole is regulated by a stop-cock. When a flue of the boiler or any part of the engine-room is overheated, it is only necessary to direct this pipe on the fire, which will be instantly damped, and the cause of danger removed, and that without inconvenience; for the fire in the furnace will probably not be extinguished, but will blaze up in a short time again after the danger has ceased. Of course this will only be of use when the furnaces are below the level of the water without, which is generally the case; and even where it is not so, a ready supply of water for this purpose in the engine-room is of great consequence. I have myself been present in a steamboat where explosion was only prevented by this means.

5. A *safety-reservoir*.—It has already been stated, that the great Hull accident arose from want of water in the boilers before starting. This is a very common cause of danger, and arises from the circumstance that it is the motion of the engine which usually feeds the boiler with water; so that if by any accident there shall be too little water in the boiler when the fires are lighted, or the fire shall burn more briskly than was expected, or some unforeseen delay shall arise, there will remain no remedy, unless, indeed, the crew shall be set to work the force-pump, which is tedious and laborious, and is not only an unwilling task to them, but exposes the improvidence or neglect of the engineer, which he is, of course, desirous to conceal. Having experienced the advantage which would occur from such an arrangement as should afford such a supply of water to the boiler, I constructed for a steamboat of 60-horse power the following safety-reservoir, by which the boiler can always be filled, even when the steam is strong, without manual labor or the motion of the engine. It is on the principle adopted by Savary in his engine, and is so simple, that it has, in all probability, been applied to a similar purpose.

A reservoir of a few cubic feet in capacity is placed on the top of the boiler, connected by pipes (furnished with cocks or valves), firstly, with the steam-chest; secondly, with the lower part of the body of water in the boiler; and thirdly, with the external water in which the vessel floats. When the engineer wishes to supply his boiler with water, he opens the first cock, and the reservoir is filled with steam; he shuts it, and the steam is condensed. A vacuum is formed; the water rises on opening the second cock and fills the reservoir. The second cock is then closed, and the two others being opened, a free communication is established between the steam-chest, the reservoir, and the water contents of the boiler. The water from the reservoir then passes into the boiler by its pressure from greater height. This may be repeated until the whole supply is obtained. The whole apparatus might be rendered self acting, but is simpler without it.

6. Of course the usual glass-gauge to each boiler, and gauge-cocks, are indispensable.

7. A rod from the chimney-damper might pass into the engine room for the purpose of checking the draught of the chimney at the same time that the furnace-doors are opened for the admission of cold air.

8. *Passenger gauges.* It would tend greatly to prevent the use of imprudent pressures in the boilers of passenger-boats if a mercurial gauge were placed in some part of the cabin, and connected with the steam-chest of the boiler by a slender pipe. This would enable the passengers always to check any excess of pressure; it may be a glass tube, rendered ornamental, and so graduated that he who runs may read. Although few of the passengers might know the nature of the instrument, there would generally be at least one of them who understood it, and would attend to the security of the passengers. It might be graduated so as to express on the scale the limit of *licensed pressure* engraved thereon; above which, to the extreme of the scale, should be written *dangerous.* I know a printing establishment where the presses are worked by steam; and in the office, at a distance from the boiler, the superintendent has a gauge for indicating the state of steam and water in the boiler.

10. *Of lights.* In this respect steamvessels are at present very defective. A common stage-coach on land is much better lighted than a large steamboat in a dangerous channel, in darkness or in fog. On the frequented rivers, Thames, Clyde, and Mersey, lighting is especially necessary. There should be a strong lamp and reflector on each paddle-box, or each bow, and another at the mast head. In a river, especially, good lamps would be of the greatest consequence, both in preventing other vessels from collision, and in showing clearly, by their light thrown properly forward, such objects as were in the way of the vessel. The possibility of doing this efficiently, at moderate expense, I have perfectly established. Powerful lamps, which I designed some years ago for the Edinburg and Glasgow canal companies, are now used by them in their night-boats, with such effect as to show clearly objects at 500 yards' distance; so that their boats are steered with perfect safety at from seven to ten miles an hour in a narrow and circuitous channel. These lights are constructed in the following manner: A box, about 16 inches high, 16 inches wide, and 12 inches deep, contains a silvered plate of copper, bent to the parabolic curve, so as to converge the rays of light vertically, and throw the force in a parallel beam horizontally in every direction before the bow of the vessel. Expensive parabolic reflectors of double curvature are in this case unnecessary, because they are not required to confine the light laterally, but allow it to spread. The lamps used by the canal company have one, two, three, and four lamps in each reflector, as considered requisite.

Vice-Admiral Sir David Milne, K. C. B.

5. I am not at present acquainted whether the engines and boilers are overhauled and repaired so frequently as is requisite. When I formerly took some management in the London and Edinburg Steam company, the most positive orders were given to attend strictly to these matters; and I know that the utmost attention was paid.

6. I cannot suggest any improvement in the safety-valves, feed, blowing-off pipes, or other apparatus, further than that the utmost attention should be given to those now in use.

7. I think mercantile steamers ought to be more strongly built, and should have greater length of floor, with greater breadth of beam, to enable them to carry such a weight of engines, boilers, &c. The beams and fastenings, also, should be of sufficient strength to hinder the frame of the vessel from working, which, in a heavy sea, causes the different parts of the machinery not to work fairly on the centres, which must occasionally be the cause of accidents to the machinery, and, in consequence, endanger the vessel.

The sails and rigging, if kept in proper order and repair, are sufficient to keep the vessel off a lee shore; but should the machinery by any accident be stopped, the sails would have little or no effect until the broken parts could be removed, to allow the paddle-wheels to revolve; for until this is done, the vessel could make no headway, from the resistance in the water by the paddle-wheels. For these reasons, I would strongly recommend that means ought to be adopted in forming the machinery, that there should be a contrivance to throw the paddle-wheels immediately out of gear, by what (I believe) is called a clutch-box. I do not believe there can be any difficulty in this, and it would allow sail to be made on the vessel at once; and should she be on a lee-shore, or near sand-banks, would, probably, be the means of saving the vessel from shipwreck.

The number of boats ought to be in proportion to the number of the crew and passengers. I would recommend that extra boats should be kept at the places where the vessels go from, to be taken on board according to the number of people embarked. I would also recommend that the boats should be of a different construction to those in present use; that is, they should be more flat-bottomed for stowage, and safety of the people, in a heavy sea. The boats should be hung to davits, and nothing allowed to be put into them, except the oars and boat hook, with a mast and one lug sail; two or three breakers filled with fresh water should also be in them, and the tackle-falls kept clear and ready for running.

8. I do not think any signals are necessary in port, except to notify the time of sailing or arrival of the vessel. At sea, I think it absolutely necessary that night-signals should be established, and made known by the newspapers, and at the different custom-houses; that the steamers will show two lights on the starboard-bow, and one light on the larboard-bow, at a sufficient height to be seen, and that all vessels should keep on that side where the two lights are shown; this will, in a great degree, prevent any collision either at sea or in a river, particularly when vessels may be rounding a point in the river. I would also recommend that blue lights or rockets should be kept at hand to be made use of on perceiving any vessel running down, apparently not keeping a good look-out, to draw their attention.

9. Inquiries should always be made as to the quality of the coal, whether it is liable to ignite, &c. A pump should be so placed that a jet of water could be instantly applied if necessary.

10. There are many observations to be made as to this query. I do not think that steamers are so safe as they ought to be. The build of the vessels I consider as not the best calculated for safety; the breadth of beam is too small for the length of the vessel. This may not be of much consequence in rivers; but in the open sea, any accident happening to the machinery in bad weather and a heavy sea, and the vessel fall off into the trough of the sea, should it break into her (which is very probable it might do), the vessel would run a great risk of foundering, from the manner they

are fitted. Great precaution should be taken in bad weather to secure the hatches and other openings from the deck, to the different places below, or into the cabins and other apartments. Should a heavy sea tumble in, steamvessels, as they are now fitted and lumbered, would run every risk of foundering. The hatches and all the openings on the deck should have high coverings; and when bad weather occurs, they should be secured by tarpaulings, battened over them, with only a small corner left for the engine-men and crew to get up and down. What is called the weather boards should all be made to open outward, that, in case of a sea tumbling into the vessel, it may run out to leeward; great attention ought to be paid to this.

I must also observe, that the way these vessels are lumbered on their decks with carriages, boxes, baskets of meat, live stock, &c., it is impossible, should a sea break on board, it could be got rid of; the vessel would be in the greatest danger, without the chance of the passengers or crew being saved.

The legislature ought to take these matters into their serious consideration, and enact such laws and regulations as may be necessary. I would strongly recommend that inspectors should be appointed at each port, and their duty be to examine the machinery, sails, anchors and cables, boats and pumps, and the loading on the deck, and to give a certificate to the captain that all is right before he sails. It would also be desirable before any person is appointed to command one of these vessels, that he should have passed as a North sea pilot, and also examine as to his knowledge of steam-machinery. I am, &c.

DAVID MILNE.

Mr. David Crighton, Surveyor to Lloyd's, Dundee.

"DUNDEE, *February* 2, 1839.

"4. I am not aware of the loss of any steamer on this coast that has not been occasioned by some defect in the machinery, so far as the circumstances are known.

"7. I am of opinion that steamers in general would be found deficient in storm-sails in such a state of repair as would be necessary to carry them off a lee shore in bad weather: as to the boats of steamvessels, I fear they would be very insufficient for saving the lives of the passengers and crews, few of them carrying more than two or three boats at the utmost; which, from the number of passengers generally on board these vessels, would be very inadequate for their preservation in any emergency.

"8. There are no established rules in this port for the prevention of collision between steamers and other vessels: it is a general understanding between steamers themselves, when meeting each other at sea or elsewhere on this coast (except in the Thames), that both vessels put their helms a starboard.

"9. I am of opinion that fires on board of steamvessels, in almost every case, originate from want of proper care. If the internal arrangements for the disposal of the fuel are judiciously placed, the best mode of preventing accidents from this cause would be, to make it imperative that every steamer carrying passengers should be subjected to a proper inspection, to ascertain that proper space was allowed for the stowage of fuel.

"10. I am opinion that all steamers which carry passengers should be subjected to minute and frequent inspections, that the state of the hull, stores, machinery, and boilers, may be correctly ascertained, and a character assigned accordingly. None of the steamers belonging to this port are ever classed at Lloyd's, or have any proper stations; it would, therefore, appear necessary that some measures were adopted to render such inspections imperative. I am, &c."

"DAVID CRIGHTON."

"5. I am of opinion that the boilers of sea-going steamers are not properly tested, although they may be regularly overhauled and inspected; what I mean by testing, is, that they are not filled with water and tried with the force-pump, to make sure of their being sufficiently strong to ensure their safety: this sort of test I would have applied at least once in three months.

"6. I would propose that, besides the ordinary safety-valves, there should be an additional one loaded to what the engineer wished put on it, and let it be placed under lock and key, so that, without the master's knowledge, no one could have access to it: this would effectually prevent the overloading of safety valves, and thereby very much lessen the risk of explosions. I am, &c."

"C. CARMICHAEL."

Mr. W. Greener, Newcastle.

GENTLEMEN: 1. The accidents to steamboats which have come under my observation are several. I shall, however, only instance a few of recent occurrence, and which have happened in this immediate district. On the 2d of September, 1838, the "Vivid," a tug-boat belonging to this port, had her boiler burst, by which two men, the engineer and fireman, lost their lives, who were joint proprietors of the boat. On the 7th, the disastrous wreck of the "Forfarshire," which has been a subject of melancholy comment almost ever since, occurred upon our coast, when a number of valuable lives were lost with much property. On the 12th, the "Tweedside," on her voyage from Edinburg, whither she had been with a party on pleasure, took fire, and placed, for a time at least, the lives of the party in danger; at any rate, a great deal of fearful anxiety was created in their minds, until another steamboat, the "Adelaide," took the passengers on board and transferred them to the "Northern Yacht," in which they safely arrived at Newcastle. Since that period another steamboat left this port which has not since been heard of, and not a soul escaped to tell the woful tale; but as I am not, from observation of the fitness of the vessel, able to give any information on the subject, and as a variety of opinions have come before the public, I shall abstain from any remarks connected with that business, having ample material for the purpose of the present inquiry in the cases I have already named.

2. I am not a boiler builder—no accident has come under my observation in the manufacture of which I have been in any way connected—and consequently the remarks I have to offer will be entirely disinterested. I have for a number of years been engaged in the working of iron which

requires great strength and elasticity, and my attention was first directed to this subject by the analogy which a burst gun-barrel bears to a burst steam-boiler; and I was thus led to make a great number of experiments having direct reference to the subject, the result of which I shall communicate as I proceed.

3. I have stated above that the boiler of the "Vivid" burst and destroyed two men. On examination of the tube of this boiler, I found a collapse had taken place from the bottom upward, which had rent the tube longitudinally full four feet, and in the contrary direction upward of two feet. The primary cause of this explosion appears to have been a defective plate, which, being exposed to the action of the fire, had caused what is technically termed a "blush," which, breaking or coming off, left the plate scarcely one-third of its original thickness, though it was subject to the same internal pressure as the other and stronger parts of the boiler. Here the first rent took place, and the rush, if I may so term it, of the steam to where it could find a vent, then caused the collapse I have described, and the lamentable consequence. The loss of the "Forfarshire" is to be attributed, I am of opinion, to the inefficient state of her boilers, for the crew were not able to keep the engine room clear of the boiling water, caused by the leaking of the boilers; thus rendering the engines ineffective, and, as it unfortunately happened in this case, producing direful consequences, as is well known. The defect here was in the seams of the boiler; they were not water-tight, and, as it happened, a fearful gale came on, which, doubtless, would cause the vessel to labor much, and consequently increase the leakage to the extent named; though, under ordinary circumstances, the vessel might, in all probability, have made her voyage in safety. The accident to the "Tweedside" was also caused by such an occurrence; some of the rivets of one of her boilers had sprung and rendered it useless, and it was in consequence of the extra application of fire to the other boiler, in order to effect their passage with half the power she ought to have had, that the boat herself was set on fire, much to the alarm of the passengers then on board.

4. I am not acquainted with any accident to steamers at sea or in rivers, but what has arisen from the defective state of the boilers.

5. I think that the engines and boilers of steamvessels are not overhauled so frequently, speaking generally, as is consistent with public safety. I have seen boilers taken out of vessels with their bottoms in a state of rottenness, and not half the substance of the iron left, the other being destroyed by rust; and I have seen the fur or deposite from the water upon the fire-tubes in some places upward of an inch in thickness: this could not have taken place with ordinary attention to the state of the boiler. In the course of my experiments on the relative strength of iron of different qualities, that of which steam boilers are made has been subjected to a variety of tests, which, I think, will show the necessity of paying attention to the construction as well as the inspection of steam-boilers, whether used by land or sea. This kind of iron is excessively bad in quality; it possesses no tenacity, it possesses no elasticity; if you put it into a testing-machine it will separate, with an outward pressure nine-tenths less than what superior iron will bear. The same test shows it possesses no tensile spring, for it separates without elongating an eighth of an inch; and if a slip of it is bent cold out of a straight position to a form similar to the arch of a boiler, a pressure of 168 lbs. to the inch will break it across like a piece of fir deal, though the sub-

stance of five-sixteenths of an inch thick. The same iron can be made ten times the strength, so that one cause of the explosions I attribute to the inferior quality of the material from which boilers are generally made. I have agitated this question locally for months, and iron-masters of high reputation have confessed they could make it much better, if they could obtain a remunerating price. This is no difficult matter. For instance, I find on analysis (of a large quantity of boiler plates which I have tried) that the component parts of inferior iron are: carbon 8, lime 2, silica $1\frac{1}{2}$, iron $88\frac{1}{2}$. Now, once reheating and hammering would reduce the above deleterious ingredients one-third, another heating another third, leaving only $3\frac{3}{4}$ alloy to $96\frac{1}{4}$ pure metal, while the quality of the material would be increased full six-fold, even with this adulteration; but then a sacrifice must be submitted to which, in the present state of knowledge on the subject, would be considered a loss: hence, the risk of the lives of our fellow-creatures for the paltry saving of a few pounds in the cost of a steam-engine boiler. Two accidents have occurred to locomotive engine boilers recently, one on the Liverpool and Manchester railway, and one more recently still, at Ghent, in Belgium; by each two lives were sacrificed. If proof were wanting, here is one of the inferior quality of the iron; here there are no tubes to get red hot (that can explode with danger) for want of water, but boilers only or barely five feet diameter, made of plates of half an inch in thickness, bursting with a pressure little exceeding 200 lbs. on the inch. I am prepared to prove they could not have more; while, if of good material, 800 lbs. would not have burst them. A perfectly well constructed boiler, if the iron is good, will expand full one-fourth before an explosion, and that would be a reduction of the pressure that would prevent, for a considerable time, a recurrence of the danger.

6. The ingenuity of many eminent men has been employed in inventing and improving the apparatus necessary for safety in the working of a steam-engine, and little appears to be wanting except a better (indeed, I may say a much better) quality of iron, and a greater attention to regularity and precision in the execution of the work; for in the same proportion as the work is irregular, by which I mean, when the rivet-holes are not exactly opposite each other, in the same proportion will the boiler be rendered less capable of bearing the pressure for which it is designed; and as I have shown that accidents have arisen from both these causes, it certainly ought to be the duty of those interested in the manufacture of these articles to attend both to the quality of the material and to the style of the workmanship. There is, however, a steamboat employed as a passage boat on the Tyne, the "Dahlia," whose engines are constructed so as to prevent the danger of explosion. One fruitful cause of this is want of water, and then the boiler or tubes get red hot; but this engine is so constructed that, when the water is low, the fire is involuntarily put out, thus superseding the possibility of an explosion from that cause. I was lately on board a steamboat where the steam-pipe was burst for six or eight inches, and bound round with rope-yarn to keep it tight.

7. The number of boats at present on board of steamvessels appears sufficient, but I am of the same opinion as Mr. G. Straker, as expressed by him at a public meeting in the Guildhall, in Newcastle, a few months ago, which was, "that every steamboat ought to have an anchor and cable of sufficient weight and strength, that, in the event of her machinery being deranged, she might ride in the open sea as securely and safely as a floating-light, not having

the same masts and yards as sailing-vessels, and the wind not having the same effect upon them; and, if so provided, there could not be the slightest danger of her driving upon a lee shore: but it would be requisite that her windlasses should be secured in a similar substantial manner to the floating-light vessels. The commissioners of the navy, with the assistance of the officers of the dock-yards of the admiralty, will be able to furnish a scale of the proper weight according to the size of the vessel." Had this been the case with the "Ardincaple," she would not have been placed in such imminent danger in the storm of September 1, 1833. It will be recollected that this vessel broke from both her anchors, and if they had not had a little canvass, by which they were enabled to wear her off the land, they must have inevitably perished; and as sails might sometimes be used with advantage, it would be well if they had a duplicate set of sails in case those in use should be blown away, as was very lately the case.

8. The regulations of the port of Newcastle are sufficient to meet all circumstances of this nature, and when collision does take place, it is generally in consequence of not attending to those regulations.

9. Steamvessels cannot well be subjected to any of the evils resulting from the causes enumerated in this query, if the most ordinary attention is paid to their condition; and the most effectual remedy against even the apprehension of those dangers is the vigilant eye of the commander.

10. In addition to what I have said in answer to query 7, steamboats might be fitted with an indicator, which the passengers ought to have access to, showing the pressure at which the engine was working, and also another stating the pressure the boiler had been subjected to in testing.

I am, &c.

W. GREENER.

48, Groate Market, Newcastle upon-Tyne,
February 4, 1839.

Mr. Golightly, engineer and foreman to Messrs. Hawks, Stanley, & Co., Gateshead Iron-works.

1. The "Vivid" (tug-boat), which had two cylindric boilers, burst in 1838 close to the quay at North Shields. The inner tube rent at the bottom under the fire-grate, from being corroded and thin. Two brothers, who with two others owned and worked the steamer, were killed. They were about to take a vessel in tow, but, finding their boiler leaky, gave it up, and were in the act of drawing out the fire from the furnace, when that boiler exploded.

The "Freedom" (tug-boat), of Stockton, exploded in 1836; her engine and boilers were made by us. She was employed in towing three vessels in the Tees, and it is supposed that the accident happened in consequence of forcing the steam to an excessive pressure. The boiler burst at the end opposite the fire-door, carried away the stern of the tug, which instantly sunk, and one of three men who worked her was killed; the other two men had come upon deck the instant previous to the explosion, and were saved.

The "Northern Yacht." Knew this vessel well; and considered her far too slight in her frame for a sea-boat, and overpowered in engines for her size and strength. She was a low vessel, with very high paddle-boxes,

which rendered her liable to sustain much damage in a heavy sea or side wind. Believes, from all he has heard, that the people of Leith sold her from finding her too weak for her power of engines to contend against the sea between Leith and Dundee, which strained and opened her, from being of so slight a build. He heard also that she had put into Berwick shortly before she was lost, because by straining she had parted her injection-pipes from the sides.

2. No other boiler than the "Freedom's" above named, has exploded of our make. Has known of frequent collapses of tubes, which are solely owing to the carelessness of the men in charge, who, not uncommonly, blow off all the water in the boilers with the fires in, and then the cold water rushes back through the blow-pipe, forms a vacuum, and produces collapse. Collapses sometimes take place of the return tube, which, though much smaller than the fire tube, is made of lighter plate and more of an oval form.

4. Believes the "Forfarshire" to have been lost from defective boilers, and the "Northern Yacht" both from defective hull and defective machinery.

5. Boilers and engines, in his opinion, not overhauled and repaired so frequently as they should be. Many of them run till they can go no longer.

6. As regards safety-valves, is of opinion that they are usually of too small an area to pass all the steam generated by the boiler when the engine stops. They should have, at least, one square inch area for every two-and-a-half-horse power. There should not, for the smallest steamer, be fewer than two valves, one of which should be able to be raised by the engine-man, and the other inaccessible to him, weighted to the pressure determined by the maker of the engines.

Feed-pipes should be so arranged that a distinct set of valves should be fixed in the pipes between the pumps and the boilers, so that if the pump-valves should be deranged, the pressure of the steam would close the others. These valves he considered better than cocks, as they shut of themselves. Cocks leak, and are also liable to be left open by careless engine and firemen.

The same box which encloses the feed-valves, contains another valve communicating with the blowing-off pipes. By shutting off the feed-water, lifting this intermediate valve, and opening the blow-off cocks, the boilers are cleaned. He finds this a simple, convenient, and effective method.

To know the exact level of the water in the boilers, he fixes a few inches within the boiler a vertical tube open at both ends; each of the three gauge-cocks communicates with this tube. By this means the gauge-cocks truly tell the height of the water; but there is no reliance upon them in the Tyne, without this precaution. The same remark extends to glass-gauges, which are apt to clog up unless well attended to; and their cocks should also communicate with an internal tube, otherwise they give no accurate indication of the level of the water in the boiler. The water of the Tyne, particularly, carries so much scum, and rises up the side of the boiler so much higher than its real level when the engine is at work, that they have frequently to stop the engine to ascertain the height of the water, and often discover it to be below the lowest gauge-cock, though when the engine was going the steam-gauge-cock may have shown water. He finds the adaptation of the internal tube, of not less than $1\frac{1}{2}$ inch bore, to be a complete remedy for this inconvenience, and to be a great means of saving the boilers from getting red hot.

He prefers the mercurial steam-pressure gauge to be attached to the steam-pipe between the throttle-valve and the boilers, rather than to the boiler; as in the latter situation it is liable to be choked with dirt.

The water of the Tyne seems also to contain some corrosive principle in its deposite; as the under parts of the fire-tubes and flues, where most of the deposite settles, become thin by being eaten away sooner than the upper parts, which are exposed to the heat of the fires.

9. The steamers on the Tyne are so small, and the coal so abundant in every part of it, that the vessels carry very little at a time, and change it so frequently, that he has never heard of an accident from spontaneous combustion, &c.

10. Is of opinion that some plan should be adopted to prevent ignorant and drunken persons from being intrusted with the management of steamers as engineers, which is too often the case. Boys of 10 to 14 years of age are frequently employed as engineers on the Tyne. Also that the engines and boilers of steamers ought to be periodically inspected; a new engine every six months; when two years old, every three months. The boilers require a thorough overhaul in two years, sometimes in one year, and are usually taken out in four years, completely repaired, and put in again, when they will last some years longer. Has known one boiler in a steamer, owned by the man who worked her, which, from his great care, he made to last eleven years with scarcely any repair. He took this boiler out, and, notwithstanding it had always been supplied with the dirty water of the Tyne, it was perfectly clean.

The average pressure of the steam in the small Tyne steamers may be rated at from 14 to 20 lbs. per square inch. These boilers, from their cylindric form and great strength, are, in his opinion, more capable of resisting this pressure than those of the flat-sided figures are of supporting 7 lbs. per square inch. The following are the strength of plates and dimensions usually used in the Tyne, as constructed by Messrs. Hawks, Stanley, & Co.;

Outside of shell.—Many of the lowest plates are $\frac{7}{16}$ thick, as the boilers corrode there first; above them $\frac{3}{8}$; and $\frac{5}{16}$ up the sides and tops.

Fire-tubes.—Plates about three-eighths at the fires, tapering to about five-sixteenths at the end. Their size depends on that of the boat and boiler, varying from three feet to two feet wide. They are not quite cylindric at the furnace part, being deeper than wide, but are gradually formed into the cylindric shape beyond the fire-bars, and diminish in diameter towards the chimney.

Mr. J. North, shipbuilder, Hull.

1. The "Union," Gainsbro' boat, in 1837, and "Victoria," London boat, in 1838.

3. I believe the explosion of the "Union" was from an overpressure of steam; another boat, intended to oppose her on the same station, was to make a trial voyage the same morning the accident occurred. As to the "Victoria," London and Hull steamer, which I built for Messrs. Brownlow, Pearson, & Co., I beg to observe that I was on board of her every trip she made when on trial; I was also on board during her first passage to London, and down the Thames the day before the first explosion took place. On all these occasions, I found the boilers could not be regularly fed. On

the passage to London, the engines were brought to a stand four times by the water being exhausted in the boiler, and requiring water to be pumped in by hand. *I strongly expressed my doubts to several persons on board, as to the safety of the engines, and nothing could induce me to go down the Thames with her on her pleasure-trip the day the explosion took place.* I considered the danger most imminent, and the event awfully proved that my fears were too well-founded. I believe the cause of the accident to have been occasioned by the very limited water-space exposed to an immense surface of heated iron, which prevented the means of ascertaining the quantity of water from operating.

As the boilers were merely repaired, without any alteration, I consider the second accident to have proceeded from the same cause.

The iron built steamers, going to sea, are extremely dangerous, from the corrosion acting upon the riveting, which is the sole fastening of the vessel.

4. I am of opinion that some steamvessels have been seriously injured by the boilers being made to wrong dimensions; in many cases timbers have to be much cut away, in order to get the boilers properly placed. One of the boats trading from this port, I am told on good authority, had her timbers cut through to the outside plank, and the boilers rested thereon: the vessel in question foundered at sea, and all hands perished.

5. Boilers are frequently overhauled when they become leaky, and require patching every voyage: they are generally expected to last three years; but it is well known that many boilers, either from misconstruction or negligence, will not last half that time. It may be said there is no fear of explosion from worn-out boilers; but the safety of a sea going vessel very much depends upon the efficiency of the boiler, as steamvessels have been lost from the boilers failing when close upon a lee shore.

6. Not being a practical engineer, I must decline suggesting an opinion.

7. Several of the steam sea-going vessels are deficient in boats; many of them, in the summer season, taking from 300 to 400 passengers, and having only three, and in no case more than four boats, which could not contain above one-tenth of the passengers.

8. Regulations which provide three lights for steamers are effective.

9. In my opinion, all the bulkheads dividing the boilers and engines from the cargo and cabins, ought to be constructed of iron.

10. As there has been such a rapid and extensive increase of steamboats in all parts of Great Britain, I think it high time that a book of registry should be exclusively established for such vessels, to contain a faithful description of them and their machinery, after a most careful survey. It may be said that Lloyd's Book of Registry contains all the necessary information; but the very contrary is the case: for how can shipbuilders and nautical men be competent to give a correct report of the machinery of steamvessels? The way it is done at present (and I speak from experience) is, that the surveyor gives a printed form to the engineer, which he fills up as he thinks proper. If I may be allowed to give an opinion, I should say it is highly expedient that a central board should be formed in London, to appoint surveyors to every port in the kingdom where the steamboats amount to twenty, and the other ports divided into districts so as to bring all under the inspection of the surveyor. All steamers going a greater distance than five hundred miles, to be surveyed every voyage, and the certificate of the survey to be placed in a conspicuous part of the vessel, so that every pas-

senger may satify himself before he embarks that the vessel and the machinery are efficient.

Vessels going coastwise, and the passage not exceeding three or four days, to be surveyed once a fortnight, and the river boats once a month.

I should recommend a practical shipwright to act in conjunction with the engineer ; their salaries to be raised by a charge on the vessels surveyed and classed, leaving it optional with the proprietor whether to have them surveyed or not. In all cases where repairs are required, notice to be given in writing by the surveyor, either as respects the vessel or engine, and the certificate to be withheld unless such repairs are immediately proceeded with.

The reports of the surveyors to be forwarded to the central board in London every quarter, with notice of vessels and engines wanting repairs ; and parties feeling aggrieved by the surveyor, to have the right of appeal to the central committee, who, in such case, will appoint a special surveyor to examine whether there is just ground for complaint.

Such precautions may not altogether prevent explosions, but it will place the steam navigation under the control of responsible and disinterested men, and prevent a repetition of those dreadful accidents which have arisen from the most shameful negligence.

I have, &c.

JAS. NORTH,
Shipbuilder and Surveyor.

MARCH 8, 1839.

Mr. Edward Gibson, shipbuilder, Hull.

"3. The accident on board the 'Graham' steamer occurred, in my opinion, by the rending of the boiler, occasioned by the engineer leaving his post, having been prompted by curiosity, after the engines had been stopped, to witness the transhipment of passengers from a large Scotch steamer—the said boiler having been well worn, and insufficiently provided with a safety-valve.

"There are good grounds for believing that the 'London' steamer did not take fire either from the mal-construction of her boilers or from the spontaneous ignition of coal, but from some other cause. The fire having commenced among the cargo in the after-hold, it is thought to have been occasioned by some of the crew smoking tobacco while working.

"The explosion of the boiler on board the 'Union' steamer, while lying in the Hull dock-basin, was, in my opinion, occasioned by the want of sufficient water, mal-construction, and the inadequacy of the safety-valve.

"The collapsing of the 'Victoria' boilers arose altogether from mal-construction, in order to generate steam in the least possible time. The watercourses were made too small, bearing no proportion to the amount of flame and heat acting on them, which rendered them not merely dangerous but fatal at that particular juncture of time. When the engines were required to be suddenly stopped (the fires being in full force), and the supply of water pumped by the engines suspended, a sufficient time was afforded for the plates to become red hot, which collapsed immediately on the vessel being again set in motion.

"5. I am of opinion that both sea-going and river packets (but more particularly the latter) neglect to overhaul and repair their engines and

boilers so frequently as they ought, to keep them in an effective or safe working state. This arises from the want of providing an extra vessel on the several lines ready to replace those requiring repairs. I am of opinion that the several parties owning these vessels are not always ignorant of the real state of their equipment, but, impelled forward by competition, they are loth to withdraw them during the season to refit, and they are suffered to ply on their respective voyages when sailing in them becomes dangerous, and accidents of greater or smaller degree, in consequence, frequently occur.

" 6. In my opinion, the majority of steamvessels employed on the seas, and more particularly on rivers, are very inadequately provided with safety-valves. Every boiler ought to be provided with safety-valves self-acting, and so placed as to be without the reach or control of the engineers. Moreover, every boiler should be provided with a good and proper index, to show the amount of pressure on the square inch at all times. This provision is miserably neglected. Scarce one vessel in ten, employed on rivers, is thus provided, consequently they work in the dark. Boilers calculated to carry only four pounds on the square inch, are oftentimes carrying eight pounds or twelve pounds, and frequently much more. The common gauge-cocks are apt to deceive an inexperienced man. He turns the gauge-cock, water gushes out; he therefore concludes that there is a sufficiency of water in the boiler, when really there is not. The water, being in a high state of ebullition, is forced through the tap.

" The several pipes required to pass through the sides and bottom of steamvessels are, for the most part, very imperfectly secured. In the majority of cases these pipes are simply inserted through a hole in the vessel's side, and turned back like unto a scupper. The straining of the vessel, striking on a sand-bank, lying unevenly on the ground, are liable to disturb them; the consequence is they become leaky, the water pours into the vessel between the timbers unseen and unknown, and this probably may have been the cause of more than one steamvessel foundering at sea. I would suggest that the holes or apertures through the sides and bottom of the vessel should, in the first instance, be provided with a copper or cast-iron pipe, with a flange at one end (say the outer end), and screwed to the plank of the bottom; then pass through these said tubes the several pipes required, and turn them on the outside, as is now done. If they become disturbed by straining, or from any other cause, the water must, of necessity, pass into the engine-room, between the joint of the first and second pipe introduced, and would at once be seen or heard by the engineer, who would cause the same to be calked and made tight, or, in an extreme case, drive in a plug, which would secure the vessel from sinking. The introduction of Samuel Hall's condensers would, if generally adopted, be the means of preventing many accidents in steam-boilers, more particularly those which arise from collapse or explosion.

" 7. I consider that the mercantile steamers generally are sufficiently strongly built, at least those on our trading coasts. The scantlings of these vessels greatly exceed the minimum of Lloyd's Regulations, which I think too small for steamships, whose length is so great in proportion to their height and breadth. The outside planking ought to be thicker than is generally introduced in many parts of the island.

" The equipment of steamers generally is very defective, the masts placed on them being more for ornament than for use. I am of opinion that every

sea-going steamvessel ought to be equipped with sufficient spars and canvass, so placed in the vessel that she may be worked or turned about with the same facility as sailing-vessels. However, such is not the fact. Scarcely one in ten would be able to keep their course at sea, or be enabled to work off from a lee-shore, should their engines become, on a sudden, disabled.

"8. I am not aware that the steamers in the port of Hull have any established regulations for the prevention of collision, either by signal or otherwise.

"9. Fires have, at different times, taken place on board steamers from three several causes: from boilers constructed with what is termed dry bottoms; from the excessive heat of that portion of the chimney which passes through the deck of the vessel; and from spontaneous ignition of the coals, when suffered to rest on the top and sides of the boilers.

"These contingencies are easily provided against. The two first causes of fire we find, in all well-appointed vessels, already sufficiently guarded against, but not so the latter. The bunkers or coal-boxes are uniformly placed in this section of the vessel, and in all cargo-vessels the arrangement is arbitrary. It is not, in my opinion, necessary that the coals should lay immediately in contact with the surface of the boilers, as is practised by far the greater number of steamers. If a false top or floor of sheet-iron was thrown over the tops of the boilers, distant from the boiler-plate at least six inches, then introduce through this floor two or more air-flues, passing upward through the deck to carry off the heated air thrown off by the boilers and the lower portion of the chimney, the coal-bunkers would be kept comparatively cool, and would remove the danger arising from spontaneous ignition of coal.

"*Remarks.*—On the broad principle, I am averse to Government interference with matters of trade and commerce. Generally speaking, evils or inconveniences arising, if left alone, will, in time, cure themselves. Strong competition ensures this, yet, notwithstanding, there are exceptions to this rule. Steam navigation forms this exception; it differs, in character, from most other interests. For instance, the conveyance, on land, by mail and stage-coaches, prospers in proportion to the efficiency of the horses, the vehicles, &c.; therefore the proprietors spare no expense in having every thing of the strongest and best quality, to ensure expedition, comfort, and safety. The steampacket owner looks only to the *splendor of the saloon* and the velocity of the vessel; it is upon these alone that he depends for success. The safety of the passengers is altogether lost sight of. To ensure speed, the fabric of the vessel is made as light and flimsy as possible to hold together. The engines are far too powerful for the bodies which are to be propelled, and the boilers are made as light as possible, having small watercourses, with the greatest possible surface for the fire to act upon, in order to generate, in the least possible time, the largest amount of steam, and that of the highest possible elasticity. It is excessive competition which induces parties to carry out these plans beyond the boundaries of safety. Seeing, then, that so many thousands of her Majesty's subjects are daily exposed to imminent danger from opposition and cupidity, it surely becomes the bounden duty of the Government to interfere.

"Steam navigation has advanced more rapidly than men of experience and knowledge of machinery can be found to conduct it; hence we often

find, in the river packets in particular, men advanced to the post of engineer who are mere automatons, ignorant of the first principles of the machine over which they preside; who, in case of any derangement, do, from ignorance of the result, the very thing which they ought to have avoided, thereby creating, rather than averting, danger or accident.

"I would suggest that boilers, on board steamvessels of every description, should not be allowed to remain in use more than three years, and that their machinery, &c., should undergo thorough inspection at least once a quarter, by a competent person appointed by the Government. That no man should be allowed to take the command of a steamvessel, and no engineer hold an appointment on board such vessel, without having passed a certain examination as to their efficiency, and who are able to produce a certificate to that effect.

"EDWARD GIBSON.

"*March* 12, 1839."

Mr. Edward Rheam, Humber Union Steam Company, Hull.

"'In some steamvessels the safety-valves are placed upon deck and loaded on the steelyard principle, which situation and method of loading I consider exceedingly dangerous, more especially in the unprotected state in which they are often left; so as to be liable, in the hurry of embarking and landing passengers, to have luggage, &c., inadvertently placed upon them, whereby the lives of all on board are endangered. The liability to accident is also greatly increased by their being placed so far from the engine-room, and altogether from under the eye of the engineer, independently of the delay which must unavoidably take place on having to proceed from the engine-room to the deck for the purpose of lifting the valve after easing or stopping the engine. I consider the safety-valves in use on board this company's vessels are upon the best principle hitherto discovered, and I am unable to suggest any improvement upon them. The valves themselves are inaccessible to any person during the time of steaming, thereby rendering it impossible to place any additional weight upon them for the purpose of driving the vessel beyond her proper speed. The weights attached to the valves traverse on two perpendicular rods, so constructed that whatever list the ship may take in a rolling sea, it cannot affect the true action; nor can any corrosion take place, the whole apparatus being of brass. They are lifted by a lever, which comes directly in front of the boilers, so that, the moment the order is given to ease or stop the engine, the lever can be instantaneously lifted, being close to the hands of the men working the fires; thus rendering it impossible, with ordinary care, for an accident to occur.

"'Of the feed-pipes, I consider an open feed decidedly the best, the mode of feeding by force-pumps being very liable to accident. The process of blowing out the boilers is rendered unnecessary by the use of Hall's condensers, the advantages of which are too well known to require notice here.'

"10. I believe a large proportion of the loss of life and property on board steamvessels will be found, on inquiry, to proceed from one or two of the following causes: first, the sending to sea of vessels originally built for

river stations only, but which, on being fitted up, are found, either from being of a greater draught of water than was calculated, or from other causes, unfit for their original destination, and are, consequently, employed wherever opportunity presents, without due regard to their capabilities. Several of this description (which it would be invidious to name) have come within my own personal observation in the different ports on the east coast, and one of which, with all on board, perished in one of the recent severe gales. The second is, where competition on certain lines is carried to such an extent, in the reduction of freight and passage-money, as to entail a serious loss upon the proprietors, who are naturally tempted, under such circumstances, to defer to the very last extremity the outlay of further capital in effecting the needful repairs. Although I am inclined to doubt the policy of legislative interference in these matters generally, believing that a fair and honorable competition is the best corrective for evils of this nature, yet, considering that a great number of the passengers by steamboats are from the interior of the country, and cannot be expected to understand the merits or demerits of the vessels on board of which they embark, I think that the safety of the community at large requires that a minimum power, size, and strength should be fixed for sea-going vessels, and that a periodical inspection should take place of all steamboats used for the conveyance of goods and passengers."

Mr. Isaac Dodds, engineer, Rotheram.

"3. In my opinion the decomposition of water, and consequent formation of hydrogen gas in the interior of a boiler, is much more to be feared than the excess of pressure. Knowing that red-hot iron decomposes water, the oxygen being taken up by the iron, and thereby producing this gas, which will be seen under the head 'Gun-barrel Apparatus,' in most chemical publications, I, upon that data, entered into a number of experiments, which confirmed this opinion. I have known instances of the plate over the furnace becoming heated, while there has been a sufficiency of water in the boiler; this was caused by there being a thick deposite of salt between the water and this plate, which heated, *blushed* and caused a fracture, which allowed the water to escape, without doing further damage than putting out the fire."

"5. I think an efficient general inspecting engineer should be kept to overhaul and inspect the boilers and machinery of every vessel once a month; but the greatest benefit would arise from a board of engineers empowered to test the competency of the attendant engineer on board, granting him a diploma certifying his fitness before he would be permitted to fill such a situation. This engineer to report from time to time to the inspector the state of the boilers and machinery, who should have full power to order such repairs, &c., as he might deem necessary for safety.

"6. I would advise a thermometer steam-gauge to be placed in the captain's cabin, connected with the boiler by means of a small pipe, which would enable him to see at any time at what pressure they were working, and would be a check to their overloading the safety-valve."

Mr. Nicholas Harvey, engineer, Hayle Foundry, Cornwall.

"5. There can be no question but that many steamers run longer than they ought before they undergo repairs—witness the 'Forfarshire' last autumn.

"6. I see no objection to the present mode of safety-valves, if ordinary care is taken, and if they are made large enough. For the blow-off cocks there should be at least two between the boiler and side of the ship, with a crooked elastic pipe (as of copper) between the two cocks, in case the vessel should strain, &c. Mr. S. Seaward, of the Canal Iron Works, Limehouse, is about to adopt a method for limiting the quantity of water to be blown off at one time; it may be worthy of your inquiry.

"Glass tubes, in addition to the ordinary gauge-cocks, I consider very necessary to ascertain the height of water in the boilers. All self-acting machines for this purpose I disapprove of.

"7. Mercantile steamers appear to me generally pretty well equipped in sails, and many are very manageable under sail; but I should say that few are supplied with boats sufficient to accommodate one-half of the usual crew and passengers, and this may be difficult to accomplish, or would be objected to. To make the most of a boat, I should recommend them to be furnished with air-vessels (made of wood or copper), placed in the prow stern-sheets, and on each side of the boat under the thwarts. In this case a boat might be deeply laden without much fear of being swamped by the shipping of a sea; at the same time a large screw-valve might be placed in the bottom of the boat to keep the water at an equilibrium in case more water came in than could be dipped out.

"9. I think that fires on board steamers generally arise from the spontaneous ignition of the coals; some kinds (particularly of the South Wales) will very readily ignite in warm weather in the open air after being damped by rain; and coals put on board a steamer in a damp state, placed near the boiler, and allowed to remain long, are liable to ignite, the more sulphurous particularly. I think that coals should never be allowed to come in contact with the boiler, and that occasionally the coal-boxes should be swept clean, as sometimes at the bottom or farther end a portion of coals remain for many months. I do not think that smoke-joints have much to do with the burning of boats.

"10. The boiler appears to be the greatest object of terror on board steam-vessels; and it certainly becomes us all to exert ourselves to prevent, as much as possible, accidents, and above all an explosion, the effects of which are so very serious. There can be no doubt but that the greatest number of accidents which happen to boilers are caused for want of sufficient water over the fire-tubes, or flues, or rather, by letting the water get below their top surfaces. This may happen from the feed-pumps being defective, feed-pipes, boiler leaking, blow-off cocks and pipes being out of order, or by general neglect and inattention. There is no machine that I know of that can be trusted with the regulation of such an important affair: if mechanical means should be adopted for this purpose, the engineers would, after a short successful experiment, trust entirely to its operation, and become neglectful; in consequence, we are dependant on the care and watchfulness of man; therefore, I think that the engineer's attention, while on watch, should be kept fully occupied, and the apparatus connected with the boiler, &c., should be made as simple and as

much in sight as possible. Many engineers, when they find the water getting low, or even dangerously so, without at the time accounting for it, generally rake the fires out, and open the blow-off steam-valve. I consider this a dangerous practice; for if the water is below the fire-flue surface, the plates thus exposed become over-heated by opening the blow-off valve; the water, which before would be in a measure tranquil, becomes so much agitated its particles come in contact with the overheated surfaces, and almost immediately the quantity of steam generated is so great that the valves cannot dispense with it; the raking out of the fires causes a greater intensity of heat while this business is in hand than ordinary firing. I have often seen steamers, particularly about the starting time, and from delay in starting, when the whole mass, boiler and water, has been heated more than usual, that with the engines working, safety-valves open, also the fire-doors, and the cold-water pumps at work, and yet it would take from fifteen to twenty minutes to reduce the quantity of steam to its usual gauge. In the several boats that I have had to superintend, I have invariably arranged conveniently for the engineer a hose and jet, communicating either with the water without the boat, or generally to a force-pump, made expressly for the purpose, with a caution that if the feed-pumps are long idle, from the boat being delayed, if the water falls to near the flue's surface, or if any thing happened to any part of the boiler, or any other part, trifles excepted, to immediately check the fires by a jet of water, and, if necessary, extinguish them; but if the water is low, or steam high, never rake the fires. I have found this the easiest and most simple way to remedy such evils. There should be a decided check put to the power of the workman in altering, at least, the weights on one of the safety-valves after it has been adjusted by the superintending engineer. If the boiler is in tolerably good repair, and ordinary precaution observed, I can scarcely see the possibility of an explosion, provided also that the construction is good."

Admiral Sir Philip Durham, G. C. B., commander-in-chief, Portsmouth.

"Admiral Sir Philip Durham presents his compliments to Captain Pringle and Mr. Parkes, and has pleasure in sending them the accompanying memoranda with reference to the queries in their letter on Steamvessel Inquiry.

"Admiralty House, Portsmouth, 30 *March*, 1839.

"5. In general I do not believe that the engines and boilers of the vessels comprising the commercial steam marine are overhauled and repaired as frequently as is requisite to maintain them in a safe working state. There are doubtless many respectable exceptions, but frequently the proprietors are induced, from the competition that exists and other circumstances, to work their vessels during a season, or to fulfil a contract at the least possible expense, without ever allowing a moiety of that rest which is as essential to the well-doing of a marine engine as it is to the animal frame; thus the engines, and the boilers in particular, are frequently worked in a very defective state, and the first notice of the evil is the catastrophe.

"The only possible remedy for this would be the appointment of some person or persons (being practical engineers) to inspect as to the seaworthiness of the engines and boilers of all vessels, the inspection to be made at least quarterly, and the result published, say in the *Shipping Gazette*, adopting perhaps a classification of letters or numbers as in the classification of ships in 'Lloyd's List.'

"6. *Safety-valves.*—The various modifications of using steam of comparatively high pressure in marine engines has led to the use of safety-valves, the weights of which are varied according to circumstances. This system must ever be dangerous, and no safety-valve can be safe which is not of fixed and permanent weight, the engineers having always the power to lift the valve from its seat, but never to increase or diminish its weight.

"*Feed-pipes.*—The plans generally adopted answer well, but the system, in occasional use, of feeding from an elevated cistern through pipes, in which are suspended a column of water equal in weight to the elasticity or pressure of the steam, which thus becomes a safety-valve, does not answer on board ship.

"*Blow-off pipes and valves.*—I have known the aperture leading from the boiler to the pipe stopped with calcareous or other deposite; care, therefore, should be taken in the construction to prevent the possibility of this occurrence. The system of valves invented by Mr. Kingston, of Woolwich dock-yard, is the best, as it is generally effective, and admits of repair without docking the ship.

"9. Danger from fire must always exist while coal is left in contact with the boilers; but if the exterior of the boilers were exposed, having an air-space round them, there would be no danger from ignition. It is also recommended that the flat, or sleepers, on which the boilers rest, immediately under the smoke-joints, be lined with sheet-iron of one-sixteenth inch thick.

"10. The appointment of proper persons to inspect the efficiency of steamvessels would prevent almost all the accidents so constantly occurring; and signals, with lights of different colors, would be highly important."

Captain H. T. Austin, R. N.

"3. Without entering into considerable detail as to the causes of accidents to the boilers of steamvessels, I believe, in cases of explosion or collapse, a want of water above the fireplace to be the true cause, from want of attention to the feed, or from reckless desire at the moment to urge a point: this real cause of destruction to the boilers I conceive to be of more frequent occurrence on board steamvessels than is detected. Steamvessels have become inefficient from leaky boilers, which is to be attributed, at the present day, as much to decay of outer casing as to rending of fireplaces.

"4. I have an impression that several have been wrecked with machinery in an inefficient state, but can instance two: 'Don Juan,' on Tarifa, and the 'City of Waterford,' on the coast of Portugal. Had the former possessed the power of *readily* working the pumps, by the engines being capable of separation from the wheels, the inner one being fixed by the

rocks, I have a strong impression that the vessel would have been saved. I consider this to be the case generally; but to insure so important an object being carried fully out, all steamvessels should be subject to periodical surveys, upon the same principles that sailing-vessels are, as relates to their insurance; this survey to state the age of boilers and engines, the weight upon the safety-valve, date of last repairs, and the probable time of continued efficiency. If worked at a pressure beyond the usual two pounds and a half to the inch, the certificate should express what proof the boilers have undergone, and the surveyor's opinion of the amount of pressure such boilers may be subject to without incurring danger. It should also state if the apparatus for *disconnecting* be in perfect order. This certificate to be appended to the vessel's register, entered in her log, and to be shown at the head of bills and advertisements respecting the movements and properties of the vessel, upon the same principle that power and tonnage are at present made known to the public; and further, that the same be extracted and displayed in a conspicuous part upon the upper deck, as also in the principal cabins.

"6. The engineer should not have the power of adding weight to the safety-valves. In cases where it may be the principle to increase the pressure according to the duty required, the necessity for the commander's acquiescence should be provided for; when boilers are worked upon this principle, it should be imperative that during stoppage a safety-valve should be raised, and a feed-pump continued in action. The height of water in the boilers, as well as the amount of pressure, should be distinctly readable *upon the upper deck*. Such information is important to the officer in charge of the vessel, and would prove satisfactory to the passengers on board, and doubtless be a cause for more watchfulness on the part of those directing the operations in the engine-room.

"7. I do not consider mercantile steamers generally, as regards their rig, equipment of sails, boats, and ground tackling, to be such as to make them capable of getting out of danger in the event of accident to machinery or vessel.

"Steamvessels, besides the usual boats on their quarter, should have a proportionate capacious boat, as in other merchant-vessels. The paddle-box boat of Captain Smith, now upon trial, may prove important; also, one proportioned anchor and cable for open roadstead duty.

"9. I have witnessed, upon numerous occasions, the woodwork in the locality of the *funnel* in a sad plight, indeed, all but ignited: in order, therefore, to avoid such risk of fire, I recommend the introduction of iron beams, and also that combings and other parts should be of the same material, as far as they are within the influence of a heated funnel.

"The open space between the boilers, as well as that between coal-bunkers and boilers, admits of the lodgement of ignitible matter, as also of flame, when drawing fires; it becomes, therefore, urgent that these spaces should be protected from such risks: also, no ignitible substance should be permitted upon or in the neighborhood of the boilers, the engineers and stokers being fineable if detected.

"There should be a space all round boilers sufficient for a satisfactory inspection at the periodical surveys; though if there be a coating on the boilers, this may not be of sufficient extent to admit of passing round (which is so desirable), still such space would afford the power of removing any injurious material there collected.

"All combustible stores necessarily kept in the engine room should be confined in iron or other protecting vessel: on no account should turpentine be deposited in the engine-room.

"There should be means, by chain or lever, of closing the dampers upon the upper deck in the event of accident to the chimney.

"I do not believe it would check enterprise or expedition if, when clearing the vessel at the custom-house, a certificate were required to be lodged, signed by the engineer and approved by the commander; that upon the arrival, and since completing for departure, coal-bunkers, bulkheads, and all wooden substances in the locality of the funnel, have been examined, and that the parts for detaching the wheels from the engines are in perfect order, and that, if required, they are ready to make oath to the correctness of this report.

"10. It should be imperative that all steamvessels which navigate beyond the confines of rivers be required to possess the capability of readily disconnecting the wheels from the engines; this would admit of their being manageable under sail, and of working the feed-pumps, though the vessel remained stationary, as well as setting the bilge-pumps in action, should the situation or position of the vessel call for it. With this in view, the power of employing the water in the vessel for the purpose of injection is of considerable importance. We had this power on board the 'Medea.'

"The object required with engines, as now fitted to accomplish this important operation, *disconnecting*, is *the power of retaining the wheel firmly in position* against the action of the sea, or drifting velocity of the vessel, during the process of separating the wheel from the engine.

"There are two plans already introduced for this purpose; one to the wheels of the 'Gorgon,' by Messrs. Seaward, a plain *friction* band; the other preparing for vessels building for the East India Company, by Messrs. Maudslay & Field.

"All steamers of magnitude should have bilge-pumps, independent of the engines, as also fire-pump or engine, with hose complete, to reach to either extremity of the vessel.

"The crews of large steamers not being proportionate to their tonnage, a small engine, fitted for pumping the vessel in the event of serious leak, appears to be worthy of consideration.

"If it be shown that vessels running short distances, working with a pressure of one or more atmospheres, have been the frequent cause of loss of life, they should be required to have more frequent surveyor's certificates, and the engineers to procure a license, granted upon a certificate of qualification and character from competent persons in their districts; this, with the arrangements for *reading* upon the upper deck the pressure of steam and height of water, will, it is presumed, lessen the risk in such cases. The engineer or responsible fireman should also be fineable if absent from the control of the boilers when the steam is up.

"Most of the large mercantile steamvessels being of sufficient capacity and stability to render them calculated for important national duties, I am led to propose the following additional suggestions, with a view to obtain a knowledge of the most available vessels for warlike or other purposes. This important object might be attained by including the following particulars in the certificate of the surveys proposed to be required on the registration of the vessel:

"When and by whom the vessel was built; where to be employed; tonnage, with the necessary dimensions for calculating it; the dimensions of the floor and top timbers; the size of the paddle and other beams, with the space between the latter; to be stated where oak or fir is introduced; the thickness and description of deck; if it be laid from stem to stern, if sunk or raised from cabin; if a poop or forecastle; the height and description of the between decks; how many passengers can be accommodated with berths, and how many in addition by introducing hammocks; the quantity of coals in tons, and days' consumption, that can be carried in coal-boxes, bunkers, or other space allotted for them; what other space, as also the capability the vessel may possess for carrying other weights; how rigged; the dimensions of the rudder, its size at the head, and how steered; the draught of the vessel when launched, with the engines, boilers, masts, and stores, on board; also, when deep, stating the weights in tons actually on board; the number and power of the engines; diameter of cylinders, and length of the stroke; name of the engine-maker; if with or without beams; what description of condenser; if the engines be worked expansively; if the pistons have metallic packings; the number and arrangement of boilers; of what material, and the thickness of plates used in their construction; what description of paddle-wheels; their diameter, as well as relative position from the vessel's centre; the height of paddle-shaft from the water when the vessel is at her loaded and light draughts.

"The above particulars would show the capability of the vessel to carry guns, the number, and of what caliber, as also what number of troops could be accommodated below.

"I recommend a *printed form* being also furnished for this return, in which other points considered requisite by an engineer or shipwright could be introduced."