was then possible, it was postponed. It will undoubtedly be completed at an early period; when we shall give its provisions, with such other matter respecting foreign patents, as may appear to us important.

Observations on the Explosion of the Boilers of the Steam-boat New England. By THOMAS EWBANK, of New York.

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

Although the explosion of these boilers is, as I believe, justly attributed to an excessive pressure of steam, there is room to suppose that one remote source of the calamity may be found in the inferior quality of a portion of the copper of which they were formed. The grain or texture exhibited in several parts appeared to me on examination to be very different from that of good malleable copper. In order, however, that its quality may be more fairly tested, I have transmitted to the committee of the Franklin Institute on explosions* specimens taken from different parts of the boiler, that they may be essayed by the apparatus of the Institute adapted to that purpose. Of these specimens No. 1 is from the inside ridge of one of the furnace doors. See *j* in fig. 1 of the cuts attached to the report of the Board of Examiners.† Nos. 2 and 3 are from the joint of the vertical flue, or steam chimney, where it was connected to the horizontal flues. This vertical flue was formed of iron, the oxide of which may be seen on one side of these specimens. This joint was two or three inches above the horizontal flues, or about on a level with the lowest gauge cock. No. 4 is from one of the water legs. No. 5, I took from the outside of one of the boilers, near the centre of its length, and on a level with the top of the arches. No. 6 formed part of the shell or roof. The quality of this appears very bad. No. 7 is similar to No. 5. No. 8 formed part of one of the stays.

It should be observed that as No. 6 is from the roof, or shell, and therefore entirely remote from the influence of the fire in the furnace, or flues, it could not be injured by heat from them. In originally forming this part of the boilers, there could be no necessity for annealing the copper, as is the case in working several of the other parts. The quality of the copper from which this specimen was taken, could not therefore be injured by the makers of the boilers, and any defect in it is not attributable to them.

If the metal had been overheated in the process of its manufacture, as is sometimes the case, its malleability would, in a great measure, have been destroyed, even when in an annealed state, and as it was *hard rolled*, it would of course have been rendered still more brittle. Judging from the appearance of the fractures of several specimens, and especially of those which have broken without previous indentation, such as No. 6, it would seem that the copper was either alloyed, or that its tenacity was injured in manufacturing.

* See minutes of the monthly meeting of the Institute for February of this year, p. 159, vol. xiii.—*CON. PTE.*

† See this Journal, page 58, vol. xiii.

The ordinances of France relating to steam boilers, make provision for *inferior* copper, used in their construction, by requiring an increased thickness. In those dated July 12, 1828, (Journal of the Franklin Institute, vol. viii. p. 403,) it is said, "If, however, the copper is not of *good quality*, one or two-tenths of the thickness given by the table should be added to the numbers thus found, for the thickness of the boiler." And again, vol. ix. page 40, "And as the tenacities of certain varieties (of copper) may be lower than this, it will be necessary, according to the quality of the copper, to increase the thickness given by the formula by about one or two-tenths of the thickness found."

The qualities of different kinds of copper, as of all other metals, vary considerably, while at the same time it is much more liable than others to be injured in its tenacity by slight excesses of temperature; hence it is of great importance in determining the thickness of the particular plates of which steam boilers are to be formed, first to ascertain their tenacity; this, indeed, is of special importance when different kinds of copper are used. It is understood that the copper of these boilers was not exclusively from one establishment.

But a previous knowledge of the strength of the plates of which a boiler is formed, does not afford *sufficient* security against its rupture: for although we may ascertain from its form and dimensions, and the tenacity of its plates, what degree of pressure it *ought* to sustain, yet this result affords no certain proof what pressure it actually *will* sustain. This discrepancy is owing not only to imperfections in, and different tenacities of, the plates, but also to our not knowing the relative *strength of the seams* where the plates are connected together. This is another reason why every boiler should be proved before being used. The explosion of these boilers is a serious call for legislative regulation on this subject. If further evidence had been required to show the utility of subjecting all steam boilers, used in transporting passengers, to a proof of at least double that of their maximum working pressure, and frequently to repeat this proof, such evidence is furnished by this explosion. It may be safely assumed that had such a law been in force, this calamity had not occurred, and that many explosions preceding this, would have been prevented. This would certainly have been true of the explosion on board of the *Ohio*, for the part ruptured in her boiler did not exceed, in some places, the thickness of paper at the time of the disaster; a circumstance which would unquestionably have been detected by a previous proof.

Mr. Potter, in his testimony in relation to the explosion of the boilers of the *New England*, says he usually carried from fourteen to seventeen inches of steam, and that the engine was intended to carry from sixteen to eighteen. The safety valve was regulated to blow off at eighteen. The steam, however, with the same weight on the valve, rose to twenty-four, and at the time of the explosion it seems to have been still higher.

These boilers, then, if proved at all, should have been tested with twice the pressure they were intended to carry, viz. twice eighteen pounds; but the result has shown what a perilous undertaking it would

have been to have proved them with twice the pressure of the lowest force mentioned by Mr. Potter, viz. fourteen, except by the water press.

By the English requisition, they would have been subjected to a proof triple their ordinary working pressure; and the thickness of the plates would have been required to be such, that their tenacity should not be injured by the proof. By the French ordinances, a quintuple proof would have been required, for although they allow a triple test for low pressure boilers, these would have been considered high pressure, and subjected to the proof accordingly. [Vol. viii. p. 33, Journal of the Franklin Institute.] It is obvious that had the boilers of the New England been required to undergo either of those proofs, the calamity by which seventeen citizens have perished, had not occurred, for the simple reason, that they could not have sustained the proof, and would consequently have been condemned.

It is true that Mr. Hall says they should have borne fifty pounds to the square inch, if there had been no previous imperfection. This is at least a remarkable assertion, and especially so, coming from an engineer, and given under oath. Whatever may be the facts or reasonings upon which it is predicated, it can scarcely be denied, that it is calculated to deceive the public on an important subject, and one which so frequently involves the loss of human life. Unless Mr. Hall can show a previous defect in the boilers, their rupture at thirty pounds (or probably less,) is a conclusive proof that he is greatly mistaken in his calculations. But while the maker of the boilers believes and testifies that they should have sustained fifty pounds to the square inch, what blame can reasonably be attached to one of his men, for using, while under his employment, little more than half that pressure?

There did not appear to me, after several examinations, any reason to believe the explosion was owing to a deficiency of water. If it had been, the horizontal flues would have shown the fact, but in these there was no sign of having been overheated. Had the temperature of the steam been at any time seriously increased from the same source, the covering of the steam pipes (carpeting) would have exhibited the proof; but this was perfectly sound on both pipes, and on every part of them.

No copper boiler, however good the quality of the metal may be, of the form and dimensions of those of the New England, should be permitted to use steam exceeding fifteen pounds to the square inch: while they continue to do so, they will exemplify, as they have hitherto done, the remarks of an intelligent writer, (vol. ix. p. 352 of this Journal,) who observes, "our boats are on the low pressure plan, but they carry from sixteen to twenty-five inches of steam, and this is nothing more nor less than high steam. The shape of our boilers is not calculated to resist such a pressure, and some tremendous accident will sooner or later occur, to spread ruin and death among the crowds who venture themselves within their reach."

Though, then, there is no conclusive reason to suppose that any serious deficiency of water took place in these boilers, there can be little

doubt that it was kept lower at the after ends, than at those in front, in consequence of the steam pipes having been connected with the boilers near the latter. By this arrangement a strong current was established towards the apertures of these pipes. The rush of the steam from the opposite ends of the boilers to escape through them, a distance of fifteen feet, would in some degree carry the water along with it, and thus have a tendency to leave those parts exposed. This effect we know is produced, more or less, by all openings, however small, as gauge cocks, &c.; but in these boilers it was still further increased, in consequence of the rapid consumption of steam by the engine, and the small proportional capacity of the boilers, they having had but twenty-four inches for steam and water room.

From the relative position of the gauge cocks, and the aperture of the steam pipes, in the boilers, it may be questioned whether the cocks could safely be depended on to show the level of the water, while the engine was in motion. The steam pipes of the New England were attached to the steam chimnies or to that part of the boilers embracing them, five feet from the roof of the boilers at their front end; being thus about six feet above the gauge cocks, which were placed almost directly under them. When the engine was in motion both steam and water would rush towards the opening of the steam pipes, and this effect would be greater immediately under those openings where the cocks were placed, than at distant parts of the boilers.

It may, I think, be safely assumed, that when gauge cocks are placed immediately (or nearly so) under the aperture of the steam pipes, they cease to indicate the true level of the fluid, while the engine is going; although they may do so, when it is at rest, and the safety valve closed.

Had cocks been placed on the after ends of these boilers, on the same level as those in front, I am satisfied that water would not have been found on the same level in both. Would not cocks so situated be an additional security in such boilers as those of the New England? and would it not be safer in all boilers, to have the steam pipes connected to them at the end opposite to that to which the gauge cocks are attached?

It is supposed that the rupture of these boilers *commenced* at the after end. Mr. Hall thinks, "in the arches near their connexion with the after end." If we suppose the boilers to have had, on an average, water at the second cock, viz. six inches above the flues, it is conceived, as very possible, to have been (when the engine was going,) as much lower at the after ends, in consequence, as before observed, of the rush of the steam to the front. These remarks, although not designed to establish the opinion above expressed, seem, nevertheless, to confirm it.

Whatever may be said in favour of "the water legs,"* in the construction of these boilers, it is conceived that they are more injurious than useful. Deposits of mud, &c. accumulate in them, which it is often difficult to remove; and, with great deference to the judgment of

* See report before referred to. This Journal vol. xiii. p. 130.

the Board of Examiners, it seems to me, that the thin sheet of water contained in them, and especially in the "middle legs," being imbedded in an intense fire, which in those last mentioned embraced both sides, the water was thereby expelled from them; not "being driven by the *steam* into the upper parts of the boiler," but by the repulsion of the heated metal.

These legs form a modification of the boilers described page 4, vol. x. of the Journal of the Institute, and the effects in both will be the same when thin surfaces are not heated uniformly. A further proof of this effect was lately mentioned to me by a friend from his own personal knowledge. Some years ago, two new boilers, similar to those above alluded to, were placed together on board the steam-boat "Legislator." The feeding pipe was attached to only one of them, a pipe being connected from it to the other; the draught of the furnace of the latter boiler was greater than that of the former, and the consequence was that the fire under it had to be damped, and sometimes taken out, in order to get the water into it.

Another circumstance which appears to be worth attending to in all explosions, is the commencement and direction of the rupture, and whether it be in the seams, or in the sheets. In many cases, the relative strength of the seams could thus be ascertained. In the examination of the boilers of the New England nothing satisfactory in these respects could be obtained, the place where the rupture commenced not being known, and the rents being in every imaginable direction. The seams were, however, in numerous instances separated in a line through the centre of the rivets, thus

The joint where the vertical iron flue or chimney was connected to the horizontal flues, was separated chiefly in this manner, and in one place to the extent of three feet. Specimens No. 2 and 3, were from this joint. No. 5 and 7 from the body of the boiler, exhibit the same line of separation.

In the explosion of cylindrical boilers, and especially of those of which the ends are blown out, as the "Atlas," "Car of Commerce," "Helen M'Gregor," &c. correct information on the line of separation would have been extremely valuable. The boilers of the above named boats had cast iron ends, when they were blown out. Was it the cast iron of the ends, or the wrought iron of the boilers, which gave way? Was the line of separation in the seam? through its centre, as above, or not? I have often regretted that the highly interesting accounts of Messrs. Halderman, Robinson, Benton, &c.,* did not give us more particulars on this part of the subject. Would it not, in such cases, be desirable to know also the thickness of the boilers at the seam, as well as that of the cast iron ends at the same place, in order to ascertain the comparative strength of each?

* See this Journal, vol. viii. p. 310, and vol. ix. p. 24.

It has been observed that the strength of cast iron ends can be increased indefinitely, but however true this may be with regard to them as separately considered, it does not appear equally so, when they are connected to a boiler. The interior force acting against the ends has a tendency to separate them from the body of the boiler, and the resistance opposed to this, is not so much the strength of the ends themselves, as of that portion of the body of the boiler to which they are united. Supposing them to be one hundred times stronger than the body, still their ability to withstand the pressure of the steam, would depend upon the cohesive force of that portion of the body of the boiler which is left between the rivets which united them to it. As there appears to exist a prejudice against cast iron ends, why not substitute wrought iron *conical* heads in their places? they could be made with greater facility than those of a hemispherical form which are used in Europe, and the metal would not be so much strained as in these latter, nor even as it is where plane ends to boilers are adopted.

In forming a working model of a boiler out of very thin copper, I adopted this figure for the ends, and I am not aware that they could have been made equally strong in any other shape. Had they been made hemispherically the metal would have been strained considerably, especially near the centre, in working it into that form.

Remarks on the Height of the Aurora Borealis, with a review of the accounts of some of the most remarkable Auroral Arches. By
JAMES P. ESPY.

TO THE COMMITTEE ON PUBLICATIONS.

GENTLEMEN,—In the Journal of the Franklin Institute for the month of November, 1833, I advanced an hypothesis on the Aurora Borealis, taking for granted that the observations of the Rev. Mr. Farquharson, of Franklin, and Hood, and Parry, and Biot, &c. had put it beyond all doubt that the aurora is formed in the region of the clouds. I find, however, by examining the report of the British Association for the Advancement of Science, to which you refer me in a note, that the author of the able report on meteorology, Mr. Forbes, considers the question of the height of the aurora yet unanswered, and, indeed, leans to the opinion of Mr. Dalton, that the aurora is one hundred miles high. As a doubt still remains on this subject, I propose to state the evidence in favour of Mr. Farquharson's opinion, in so plain a manner, that it will be impossible for any person, who examines the subject, to reject the conclusion that the aurora is in the region of the clouds. And as Mr. Dalton's name alone has great weight, and deservedly too, as he has done so much for meteor-