

## COMMUNICATION

FROM

W. W. GUTHRIE,

ON

*The causes of explosions of steam-boilers, and the remedies to be applied to prevent the loss of life and property resulting therefrom.*

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CINCINNATI, December 14, 1850.

DEAR SIR: I take the liberty of sending you a communication containing a few suggestions of my own, based upon my own actual experience, upon that engrossing subject, "explosions of steam-boilers," together with some plan, which has long been a matter of desire to accomplish, for the benefit of the human family.

So many modes have been suggested, that the people have come to the conclusion that there is no alternative but to submit to the risk and loss of life and property. Many of these plans are objectionable because they generally embrace the same principle—namely, *depriving* some of the privilege of being employed, and of employing whom they please, and where they choose to be employed. In this country no such law can be passed; and if passed, will be of no effect, and will not stand.

The great question is, what are the causes of explosions? and the next is, what remedy can be applied? If we can truly find the cause, the remedy is easily arrived at. Now, upon a subject where there is such diversity of opinion, and from truly great minds, it is not for one like me to approach or to attempt any learned display, either in words or figures, for I generally deal in matters of fact more than in theory; nor would I now attempt anything of the kind, but for the fact that almost every day we are called upon to read an account of some terrible explosion, causing immense loss of life, to say nothing of the loss of property. But what I have to say is from my own experience. Deeply impressed with the truth of these impressions, yet preferring to test them more fully by the experience of others and the results of their labors, I have been content to look on, and have seen the failure of nearly every expedient that the mind of man is capable of advancing. I have even felt a delicacy in putting forward any of my experience, except in private conversation; and now, if the few

remarks sent you will be of any service, or will throw any light upon the subject by which a law can be framed, they are at your service, and you can use them or throw them aside.

Respectfully, yours, &c.,

W. W. GUTHRIE.

Hon. D. STURGEON,  
U. S. Senator.

[Endorsed.]

MY DEAR SIR: My brother William enclosed the communication herewith transmitted for my perusal and correction; but my time is so much occupied with other matters, that I cannot undertake the task.

I agree with him in the main, and think it full time that Congress should do something towards reforming the evils referred to.

The bill which passed the House last session is entirely inappropriate to the western steamers; and if enacted into a law, cannot be enforced beneficially.

J. B. G.

#### EXPLOSIONS OF STEAM-BOILERS.

There are three known causes generally given in explanation for an explosion of a boiler, or the collapsing of a flue:

1st. Incompetency of the engineer in charge.

2d. Insufficiency of water in the boiler.

3d. Over-amount of pressure for the strength of the boiler.

In an investigation of these causes, any practical engineer or theorist will at once admit that they are all so intimately blended in each other, that perhaps in no one instance did ever an explosion take place without each bearing its proportion of blame; yet, either one separately would undoubtedly cause an accident of this kind, and any discussion on any one of these points alone as a cause will prove very unsatisfactory, for two of them at least cannot be separated, and in general all accidents or explosions must be attributed to "*increased pressure.*"

1st. The incompetency of the engineer does not consist in his incapacity to undertake or not being capable of taking charge of a boiler, but in the known fact that we are ignorant of the full extent of the generation, power, and elasticity of steam, and its sudden and instantaneous accumulation. This fact is proved beyond a doubt by the explosions of boilers when in charge of men of well known reputation, of experience, and of capability.

2d. Insufficiency of water. This cause has seldom if ever produced an explosion, but it has produced what is termed a "collapse of flues," which is never so disastrous in its results as an explosion, and is caused by the water coming in contact with the heated iron of the flues: for instance, in the careening of a boat, the water will very naturally find a level—consequently some of the iron will become red hot, and, in coming in contact with water, will necessarily weaken it: then if there be pressure, the iron will give way. Now, no engineer should be held responsible for this, for it is not in his power to prevent passengers and others from run-

ning on one side of the boat. It is also a mistake to suppose that when water is too scarce in the boiler, the sudden injection of either warm or cold water will produce increased pressure: on the contrary, it will diminish it, for in no case can the water be thrown into the boiler with a temperature equal to what is already there; and unless the temperature is at least equal, there can be no increase of pressure arising from it. Hence an explosion from this cause must be attended with over-amount or increased pressure.

3d. Over-amount of pressure to the strength of the boilers. This is the evil; and here lies the root of all the disasters, with their attending loss of life, that have ever occurred; and there are so many of them, that it is time something was done to prevent them. This cause so fully involves the character of the engineer, that it is almost impossible to separate negligence from ignorance when an explosion occurs. No man knows fully, either by theory or experience, the sudden accumulation of steam, and its consequent power or elasticity, as used by all. I will give you some of my own experience in the use of this agent, in illustration of these facts. Take the common safety valve, loaded to a pressure of 125 pounds to the square inch (area,) steam not of sufficient power to raise the valve, and let there be but a momentary suspension of its use; then resume its use, and there will be seen a sudden increase in the power of steam beyond all human calculation. Remember, this increase does not show itself until a communication is opened with the atmosphere from the boiler; that is the moment when this sudden accumulation takes place, and is accounted for by the fact that, in the process of generating steam, the pressure must not be too great on the water, else steam cannot rise, unless a communication is open for its passage; but if the passage be closed, no bubbles can rise, and the water is surcharged; and when a passage is opened, who can tell the amount of the increase, or who be responsible for its effects, under existing circumstances?

There is one other point in illustration of over pressure being the cause, and man the instrument to produce it, through ignorance. Suppose the valve to be loaded at 125 pounds to the inch: so long as steam does not raise it, we are sure that there is not that amount, though we cannot tell exactly; but let the pressure raise the valve, and who can tell how much more there is? No one—it is all guess-work. Now, suppose that a boiler had been once strained at 150 pounds pressure: to approach that point again would be dangerous. To argue differently would be to suppose that a substantive material is not susceptible of wear and tear. And let one of those momentary stops take place, the steam being at a pressure of 125 pounds; can any man calculate the increase? No one looks for a moment at the consequences, until the results happen; and then all cry out, "the engineer is incompetent, and the water was too low in the boilers." But there is another curious fact connected with this cause. The engineer knows, so long as his valve does not rise, that steam is below his usual point; but after the naked valve rises, he begins to hang on more weight to the end of a line running over innumerable pulleys, the friction of which he is wholly ignorant of—all is guess-work. But suppose we guess at 5 pounds additional, (it is as likely to be 20 pounds;) that looks small, and incapable of producing any disaster, but the amount on the whole boiler is frightful. Take a boiler 42 inches diameter, 30 feet long—the circumference is 131 inches: then  $30 \text{ feet} \times 12 = 360 \text{ inches}$ ; then  $\frac{131}{2} \times 360 \times 5 =$

167,000 pounds or about 59 tons pressure upon a boiler already strained to its utmost. There are many other facts which have suggested themselves to me, calculated to make me doubt my own abilities as a competent engineer. How far others have observed them, I do not know; but, having witnessed the failure of other views, I will no longer hesitate about my own.

The next question is, how can these evils be avoided, and what agents are to be controlled? It is evident that if we can control heat or fire, and steam, the whole difficulty is surmounted: either of these agents has produced loss of life, and in the case of explosions the loss is the result of both. But explosions can, and have, taken place by and under diminished heat; and a collapse has been the result of increased heat without a corresponding increase of steam; hence it is necessary to control both, particularly as steam is produced by heat. In order to illustrate this, it will be necessary to show from experience what has actually taken place. First in regard to heat: flues of boilers have been collapsed by the careening of a boat, whereby one or more of them became exposed to the direct action of fire, and the iron is necessarily weakened, when, upon coming in contact with water, (the result is increased pressure, but it does not follow that the mere pressure is the cause of the collapse, for the pressure may have been incomparably less than the boilers have before sustained, yet it requires pressure to cause the result, but not to the extent that is generally supposed,) the expansion and contraction necessarily weakens it, and it must give way; on the other hand, steam will continue to increase after the fire has been diminished, because the heat is so distributed over a large body of water, iron, and steam, that its decrease is slow, and so long as its temperature is above  $212^{\circ}$  it will produce steam. We also have a greater proportion of increased steam as we rise in the degrees of heat than the increase of heat would seem to warrant. For instance, by experiments in the Franklin and other Institutes, we find that it requires  $212^{\circ}$  heat to produce a pressure equal to the atmosphere, 15 pounds to the inch; and it requires  $250^{\circ}$  heat to produce 30 pounds pressure: in other words, it required  $38^{\circ}$  heat to produce 15 pounds pressure of steam, when  $350^{\circ}$  heat gave 135 pounds pressure, and  $358^{\circ}$  gave 150 pounds: in other words,  $8^{\circ}$  heat produced the same result (15 pounds pressure) that it required  $38^{\circ}$  to do before steam became of any use as a propelling power. It is evident from these facts that the power of steam is increased in greater proportion than heat; hence it becomes necessary to provide a remedy against *undue heat*, as well as against *undue pressure*. Suppose, for instance—and no doubt the case has occurred often—that a boiler has already 125 pounds pressure, and one of the flues becomes bare and exposed; is it presuming too much to suppose there is  $8^{\circ}$  additional heat thrown upon that exposed surface, the result of which is 15 pounds additional pressure? No; this very fact explains why only one boiler gives way, as is generally the case, from a collapse. I know of nothing that will so effectually save the public from loss of life and property as the enactment by Congress of a law prohibiting the use of steam above a given point—say 100 pounds steam to the square inch—based upon a test pressure by hydrostatic power of at least double that amount. This will guard us against accidents arising from increased pressure; for every one knows, who has ever been engaged in using this powerful agent, that at 100 pounds pressure, man can effectually control it; but over that



amount, the ingenuity of man has not yet been able to master it, even in the production of material to contain it; and experience has also shown that there is no safety for man or property at any amount above 100 pounds. Even the engineer in charge, I care not how reckless he is, is always in dread; though, to keep up appearances, and forced by circumstances, he is compelled to risk the lives of all, in order to retain his situation. Many, no doubt, go on through ignorance; but the man that can assert that he feels under no apprehension while employed in the capacity of an engineer is not fit for the trust, nor should he be allowed to retain his position.

In regard to a remedy against "undue heat," there has nothing come under my observation, so effectual, so simple, as "Evans's safety-guard," the invention of Mr. Cadwallader Evans, of Pittsburg. This invention is invaluable, and is acted upon, or has its action, from "increased heat;" being placed upon the flue of the boiler, it is impossible to impart heat to the flue without also affecting the safety-valve: it has its action solely from heat, and is not affected by pressure, nor does it indicate increased pressure, only so far as the pressure is the result of heat above its fusibility, the alloy being made to fuse at a given temperature. But the beauty and value of this invention is its effectual guard against accidents arising from "insufficiency of water," and the exposed condition of the flue in cases of careening. The heat is certain to act upon it, and it must and will give notice. Not only does it give the notice of danger, but by its action does effectually prevent the accident or calamity from taking place. It does so from the fact that, by its action, it opens a passage for any increase of pressure before that pressure takes place; a vast difference, you will observe, from that of waiting for the increased pressure to open a way for itself, which it sometimes does with terrible results.

I have tried in this communication to give you as correct an idea of the causes of explosions of steam-boilers as my time will admit, without going into details, which would be more satisfactory to myself, but which would tire your patience, and perhaps be less satisfactory; and the nature of the subject is so full, and so much can be said on it, that with a few remarks I will close.

I think I know the feelings of nine-tenths of the engineers, and can safely say that they would hail with delight the passage of a law by Congress, enforcing some such views as have been suggested. The entire community, you know, want some protection against these too frequent disasters, and any legislation, not involving the rights of citizens, or a few, would be better than none.

There are but two points to legislate on: 1. A law compelling all persons using steam as a motive power not to go above 100 lbs. to the inch, based upon a pressure, by hydrostatic power, of at least double that amount. 2. A law compelling all steamboats to place "Evans's safety-guard" upon each outside boiler, (when there are more than one.)

There are objections arising to each of these, which would at first seem insurmountable. First, reducing the power to 100 lbs. would necessarily affect all who have built their boats and machinery adapted to the present use. Let the law so declare that it does not affect anything now in use, but only those yet to be constructed: in less than five years they would all be out of existence, for three years is more than the average of a boat's life, and five years is the average of one who follows it, in its present

form. Second, the navigation of our western waters requires extreme power, with small weight, on account of depth of water. To suppose that the mind of man would not overcome this obstacle, would be ridiculous: on the contrary, the passage of a law like this would open a new field to our mechanics and men of genius, and we would soon have a new order of things; besides, it would tend to place all this business in the hands of responsible men.

In regard to compelling all boats to use "Evans's safety-guard," there would be some opposition—for the invention has its enemies as well as its friends. The objections to it arise from the fact that many engineers have testified to its being an infallible cure and preventive against explosions; when it is well known that accidents have happened under it, in which case its friends have always tried to produce the impression that the engineer in charge had tampered with it—thereby destroying its usefulness; when, if there had been a candid admission on the part of its friends that these accidents arose from a cause (pressure, as I have endeavored to show) beyond its control, or what it was designed for, they would have been generally adopted. But after an accident takes place under the operation of an invention which has for its object a preventive, it is looked upon with suspicion, and is usually termed a humbug. Now, such has been the history of this truly great invention: at first, it went into rapid use, and was being placed upon all steamboats; when one or two of these occurrences took place, it went back as rapid as it advanced, and for a number of years has been laid on the shelf. Public attention is again being called to it; but years will go by before it recovers its former position. Mr. Evans, I think, never claimed for his invention these extreme powers; but his friends did, and that killed it. But in cases of "*undue heat*," there is no mistake about it; it will not only warn you that there is danger, but will, by that action, provide a remedy to avoid it. In my opinion it has no equal. But it will be said that Congress has no authority to pass a law compelling boats to adopt this or that invention, and make them pay for it. So far as I am able to learn, opposition to a law of this kind arises from the fact that Congress compels them to pay Mr. Evans a premium on an article that they consider of no importance. That could be obviated by purchasing the right to use it from Mr. Evans, and make its use a gift to the world. The public are deeply interested in the matter; therefore, it would be a public benefit. Congress has thrown away millions upon less worthy objects than this.

I cannot close this (too long) communication without calling your attention to one or two facts connected with the remedies proposed by many for these too frequent disasters.

It is supposed by many that if Congress would pass a law establishing a board of examiners to pass judgment upon the merits of engineers, and say who shall and who shall not, who is capable and who is not, to have charge of the boilers and engine, much if not all the difficulty would be removed, and these accidents would cease—thereby throwing all blame upon the engineer. I think I have shown that he is not always responsible for accidents of these kinds; and if I have not clearly done it, here is a fact that will at least show there would be no security under such a system. Alabama has passed a law (I think in 1836) establishing a board of examiners for this very purpose, and with full power to say who shall and who shall not run an engine—making it

an offence punishable by imprisonment and fine to resist their decrees; and that board have exercised the authority without mercy, and is composed of some five practical engineers commissioned by the State authorities. Now, what will you say when I tell you that members of this very board of examiners have been launched into eternity without a moment's notice—victims to their own ignorance? But we need not go to Alabama for evidence to show that this is really no remedy. We have among us societies of engineers, composed of good and reliable men, whose sole object is to protect each other from the encroachments of what is termed "strikers," (a term for ignorant engineers,) and yet we see almost daily these men fall by the same disasters—all alike are liable. Do not understand me to be opposed to employing good, reliable men; on the contrary, none should be engaged to take charge of boilers but those of good moral character—men of merit and of intelligence. But I have cited these facts to show that there is no security under the system proposed, nor can there be so long as steam is used in its present power, and that men ought not to be held accountable for results entirely beyond their control. Congress should pass a law limiting the amount of pressure and other guards for safety; then, if an accident happen, hold those in charge responsible for life and property to the fullest extent: because, first, experience has shown that man has capacity to control steam at that pressure, both in its effects as well as in the strength of material to contain it; second, in case of an accident, the fact would be self-evident that gross neglect and indifference was the cause.

All of which is respectfully submitted, by

Yours, respectfully,

W. W. GUTHRIE.

