Boiler Safety Bulletin

ISSUED BY THE

Industrial Accident Commission

of the

State of California

SAN FRANCISCO, CALIFORNIA

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The Fidelity and Casualty Company

ROBT. J. HILLAS, President

of New York

92 Liberty Street
New York

D. C. HARVEY,
Superintendent of Inspections

April 29, 1921.

ANSWER TO LETTER OF

Mr. J. H. Petherick,
Chief Inspector,
Balfour Building,
San Francisco, California.

Dear Sir:—

Re: HORIZONTAL TUBULAR BOILERS—
ONE SHEET ON THE BOTTOM
TYPE OF CONSTRUCTION.

Last week a boiler in a Saw Mill at a plant located in the south exploded, killing two people, injuring several others and causing heavy property damage.

At this writing, complete details are lacking but from what we have received, the boiler, which was of the Horizontal Tubular type, was constructed with one sheet on the bottom and one on the top. *The boiler gave way because of a hidden lap seam crack.*

We wish to obtain at once a list of all such boilers and the plants at which they are located.

Will you go over your records carefully and advise us if you have any such boilers at plants in your territory and if so, the names and locations. *In addition we want to be advised of the age of the boilers.*

Read carefully the instructions with regard to this type of boiler in the Book of Inspection Rules and follow them in making your inspections. Further instructions will be issued shortly.

We will ask you to give us the information asked for promptly.

Yours truly,

D. C. HARVEY, Superintendent.

CALIFORNIA'S SAFETY ORDER SYSTEM.

By WILL J. FRENCH, Chairman Industrial Accident Commission.

When the California Workmen's Compensation, Insurance and Safety Act was in course of preparation, a study was made of existing safety laws in different states and countries. The experience of a large group of other jurisdictions was ascertained. Consultation followed with California employers and employees, as well as with citizens in all walks of life. The consensus of opinion favored the plan in operation in Wisconsin, whereby safety standards were issued by the Industrial Commission, and these standards can be changed at any time or exemptions issued to meet unusual conditions. The only other feasible plan was that of having the legislature definitely state in statute how machinery of all kinds should be protected. There could be little or no flexibility under this plan. Its cost to California's employers would have been enormous, because there was no organized safety movement in the state and the field was virgin.

The legislature of 1913 approved the plan of assigning to the Industrial Accident Commission the work of issuing safety standards for the different industries. It is interesting these days to recall the activities of a large group of employers in favor of the plan adopted, because there were pending bills calling for specific safety installations that were drastic in character.

It is a fair question to ask the experience of the intervening seven and one-half years since January 1, 1914. About twenty of the largest industries are governed by safety orders. Other industries will have their standards set just as soon as it is possible for the Safety Department, with its inadequate force and lack of finances, to handle the work. This doesn't mean that general supervision has been impossible. The law requires that all places of employment shall be safe for the employees therein, and employers have cooperated with the Commission in a commendable way.

While the Commission has authority to issue standards of safety of its own preparation, so far as the industries are concerned, that course never has been followed. The law gives authority to appoint "advisers" to assist the Commission. The importance of participation by all interested groups in considering safety standards has always appealed to the Commission, and the members of each committee were selected by their respective organizations. In no instance was a committee "hand picked." Letters were invariably mailed to the employers' organization, to the trade union, and to different associations interested in the industry under consideration. Employers and employees predominated on each committee, and the engineers of the Commission's staff only held one or two places. Consequently, tentative safety orders were issued by a group of men with special knowledge of the industry's requirements. They were sent broadcast in printed form for criticism or suggested change. Public hearings were called in San Francisco and Los Angeles. Legal notices appeared as required by law, but, recognizing the fact that but few persons see such notices, carefully prepared statements of the contemplated public hearings were sent to all the daily, weekly and monthly publications in California, together with statistical information about deaths and injuries in the industry.

To each public hearing came the product of the study and planning of the committee in the form of tentative standards. The experiences of other states had been utilized. The widest publicity was given the hearing. A member of the Commission presided. No limit was placed on speakers in any way. Each word of criticism or recommendation for change was taken down by a reporter and referred back to the committee that prepared the tentative orders. An invitation was extended to those interested to meet with the committee, in order that there should be complete knowledge of the proposed changes. After the fullest deliberation, the committee drafted the safety orders with the experience of the public hearings as a guide, and recommended their approval by the Industrial Accident Commission, to become effective at a date in the future which would give time for compliance. Such extraordinary care was followed in the process of promulgating each set of safety standards that, so far, it has been unnecessary for the Commission to question the advisability of following the committee's recommendations.

This history is needed. The men on the Industrial Accident Commission and on its staff have had, and still have, for their goal reasonable safety, intelligent administration, the exercise of the power to issue special orders and grant exemptions when justified, and a total avoidance of what might appear to be arbitrary methods. An appeal to the Commission is always solicited if an order is considered unreasonable or if there is objection to the ruling of a member of the staff. The use of home-made guards is advocated. The reduction of expense is admittedly important and is aided, provided that safety will not be sacrificed as a result.

The right hand of fellowship has been given the Commission by a large majority of the employers and the employees in California. It is no idle boast to say that every effort has been put forth to merit the confidence, even though the task has been difficult and the road not always smooth. In spite of these obstacles, it is felt that no small part of this confidence has been earned. While on the one hand the Commission will continue its broadminded policies, on the other hand a continued and increasing measure of cooperation from employers and employees is essential for the benefit of all.

THE NEED FOR BOILER SAFETY ORDERS.

By H. M. Wolflin, Superintendent of Safety.

After reading the article on "The Single-Sheet Lap-Seam Boiler," by J. P. Morrison, on page 26 of this bulletin, it may be interesting if a few additional facts are presented concerning the frequency of boiler explosions and the finding of defects that lead to such explosions.

In a pamphlet entitled "Steam Boiler Explosions," published by the Fidelity and Casualty Company of New York, and delivered at Cornell University in the form of an illustrated lecture, by their Superintendent of the Department of Steam Boiler and Fly Wheel Insurance, Mr. Boehm opens his remarks by quoting the frequency of boiler accidents and explosions, annually in the United States. He states that there are between 13,000 and 14,000 serious boiler accidents, of which from 300 to

400 are violent explosions. These mishaps kill between 400 and 500 persons and injure 700 or 800 more, beside destroying over one-half million dollars worth of property each year.

Mr. Boehm then gives details of the killed, injured, and property losses occurring in a boiler explosion at the R. B. Grover Shoe Company, at Brockton, Massachusetts, and points out that the explosions of fire-tube boilers are more numerous than those of water-tube boilers. He also indicates that these facts emphasize: (1) The necessity of constructing and installing steam vessels and their appurtenances in as nearly perfect a manner as possible; (2) the importance of preventing carelessness in their operation; (3) the wisdom of having them inspected at regular intervals by disinterested experts; and (4) the desirability of forethought in securing an adequate amount of insurance to pay the loss if an explosion occurs.

He states that it is of the utmost importance that boilers be carefully designed, that the known stresses to which they are subjected be accurately computed, that suitable material be specified, that the material be critically examined for flaws or defects, that specimens of the material be tested to determine its strength, that no abuse of the material be allowed in the process of constructing the boiler and that the completed boiler be subjected to a thorough inspection and a hydrostatic test before being put into service.

Then follows a dissertation upon the method of determining some of the stresses in the shells of boilers, the bursting pressures, culminating in the statement that "It is usual in boiler practice to fix the allowable working pressure for a new boiler at one-fifth the computed bursting pressure and to *decrease the pressure allowance as the age of the boiler increases.*"

Mr. J. H. Petherick, chief inspector of the Fidelity and Casualty Company of New York, has called attention to a letter which he has just received from Mr. D. C. Harvey, superintendent of inspections, concerning a recent explosion of a lap-seam boiler located in a sawmill in the South. This is another instance of a lap-seam disaster which may be added to the long list of boiler accidents resulting from this method of construction. The letter is dated May 6, 1921, and reads in part as follows:

"The boiler was of the Horizontal Tubular type, 66 inches in diameter and 16 feet long. The age of the boiler has not been determined but it was at least 13 years old and was constructed with one sheet on the bottom and one sheet on the top, with lap longitudinal seams extending from head to head. The seams were inaccessible for inspection on account of the tubes on the inside and the brickwork on the outside. The boiler exploded violently, killing two men, injuring several others and causing heavy property damage. The explosion occurred in the early morning between five and six and just as the plant was being gotten ready for the day's run, and our advices are that the steam pressure on the boiler was about 80 pounds.

"The explosion was due to a hidden lap-joint crack developing about 18 inches from the front head on the left side of the boiler. The crack was about 2 feet long. The initial rupture took place at this crack and extended for 6 feet through the net section of the seam, then for another 6 feet through the solid plate to rear head.

"The boiler opened up flat, shearing the rivets in rear head seam and breaking the front head into three places, also breaking the cast iron manhole frame in several places.

"The six other boilers adjacent to the one that exploded were knocked off the settings and the building was entirely demolished.

"The explosion of this boiler is another striking instance of the unreliability of the lap-seam type of construction."

Referring once more to Mr. Boehm's address, I quote from page nine:

"Besides our ignorance of the dependable strength in all parts of the plate, there is also our ignorance of the character of the workmanship in the boiler. We can not be certain that all rivet holes come fair, or that incipient cracks have not been set up by an abuse of the material during the process of construction.

"It is seen therefore, that factors of safety are really made up of two parts—one part a true factor of safety, the other a pure factor of ignorance. *If this matter were better understood, boiler owners would themselves insist upon a computed factor of safety of not less than five and they would not be so persistent, as many are, in demanding that their boiler insurance company grant an unwise increase of pressure.*"

The remainder of the address is devoted to an explanation of some of the causes of boiler explosions, the time required to attain pressure sufficient to rupture, and an explanation of the energy stored in the hot water in boilers.

There follows an interesting quotation from a book entitled "A Manual of Steam Boilers, their Design, Construction and Operation," by Professor R. H. Thurston, who was in his day one of the foremost authorities on this subject. On page 645, Professor Thurston says:

"The experience of the steam-boiler inspection and insurance companies indicates that, in the United States, not less than a half, often two-thirds, of the boilers inspected may be expected to be found more or less defective and perhaps ten per cent in a dangerous condition. Of the boilers which are not subject to constant supervision and frequent inspection nearly all may be assumed to be defective, and a large percentage dangerously so."

As tending to substantiate the claim of Professor Thurston, I quote statistics of the Hartford Steam Boiler Inspection and Insurance Company, published in their quarterly magazine *The Locomotive*: In the year 1920 this company made complete internal inspections of 393,900 boilers, they found 1139 of them uninsurable, and the inspectors discovered 212,739 defects, of which 23,063 were rated as dangerous. To show that these statistics for one year are not abnormal, but represent a fair average over a number of years, I also quote the complete figures of the Hartford Company since the year 1866 up to December, 1920. In the 54 years included, this company made 3,832,669 complete internal inspections, condemned 29,978 boilers and discovered 5,492,424 defects, of which 603,683 were considered dangerous. These figures may be substantiated by referring to page 184 of the April, 1921, issue of *The Locomotive*.

From the foregoing the need of careful boiler inspection is apparent. Unless standards are developed for these inspections there will be a wide variation between the findings of individual inspectors. The possibilities of these variations have become increasingly evident, as shown by the records of the Department of Safety which is responsible for the inspection of some 3,500 uninsured boilers each year. If it is difficult to secure uniformity among relatively few men inspecting boilers, where they are working under the immediate supervision of one man, certainly there will be greater difficulty in securing uniform practices in inspection, operation or construction of boilers where the work is performed under the supervision of many different individuals. To assist in securing this uniformity and thus increase the safety of employees, with a minimum of hardship on employers, a practical, workable set of safety orders covering these points was prepared and made effective in California, some four and one-half years ago. Each year since that time some 20,000 boilers have been inspected under the provisions of these standards. Not only has this experience shown beyond question the need for the Boiler Safety Orders, from the standpoint of safety, but it also has indicated the desirability of making a few minor changes in their provisions. These changes are under way.

SOME OPINIONS OF THE A.S.M.E. BOILER CODE.

By R. L. Hemingway, Chief Boiler Inspector.

Another article in this bulletin gives a brief history of how the A.S.M.E. Boiler Code came to be drafted. It may be of interest to many of our readers to learn how this code is regarded, not only by those who drafted it, but by others who are concerned in its application, and still others whose opinions of a technical engineering specification of this kind, if the opinion of experts is to carry any weight, must convince even the most skeptical of the absence of selfish motives in the preparation of the code.

Hitherto, in dealing with scientific subjects, it has been common practice for individuals to record the results of their observations, experiments, experiences and knowledge gained through years of research, in the form of individual books. Such books, while of immense value to those interested in the subject covered, seldom carried the weight that does the A.S.M.E. Boiler Code. This code is not an expression of opinion of one man, resulting from individual effort, but represents the combined views of many of the recognized highest authorities in the United States. It goes even further, since the committee that drafted this code was not content to accept the views of Americans and American practice alone, but sent one of their members to Europe where an exhaustive investigation of the government rules of European countries was made, in order that this American Society of Mechanical Engineers' Boiler Code might not fall short of the high aim that the individuals on the committee desired to attain when they undertook this work of universal value.

The society in the past has given to the engineering profession a great deal of information that has been of immense value, and all of it is disseminated broadly among its 14,000 members without extra charge. It is doubtful, however, if any work that the society has ever undertaken is of more value or of greater importance than this boiler code, representing as it does the last word in steam boiler specifications and assuring to the United States that freedom from preventable boiler explosions which European countries have long since attained. There can be few, if any, who will deny that the record of boiler explosions, with the accompanying loss of life and property in the United States, is a strong indictment against this country for its lack of progress and its failure to keep abreast of the times.

One of the keynotes of modern progress is conservation, whether it be of natural resources or, equally as important, human life. Next in importance, probably, comes property. The possibility of immense loss to both human life and property that may occur from the sudden release of the pent up forces contained in the modern steam boiler are hardly ever realized by the layman, and it is difficult to bring home to the non-technical mind any idea of the immensity of these forces.

The boiler code of the American Society of Mechanical Engineers is designed to safely control these forces and if it did nothing more, it has performed a service that commands the gratitude and respect of the entire nation.

In the face of the facts given above, and they are incontrovertible, it is surprising to find that efforts have been made to combat the continuance in force of this code in California. As soon as the Industrial Accident Commission understood that this attack was to be made, a number of letters were written asking for opinions of the A.S.M.E. Boiler Code. Excerpts from some of these opinions will be found appended. It is interesting to note that none of those who answered the letters condemned or criticized the A.S.M.E. code. The specious argument adduced by local opponents of the code, to the effect that its adoption in California would act in favor of eastern boiler manufacturers and react detrimentally to the industry in California, will not stand even the most elementary analysis.

Regardless of what code California puts into effect, eastern manufacturers will build in competition with local builders. If California should draw a special code of its own, eastern competition will continue, but the boiler users of California will pay more for the special specifications. On the other hand, if California should take the unthinkably retrograde step and revert to the conditions of placing the boiler users and the employees of the state at the tender mercy of eastern manufacturers, with no restrictions, then the local manufacturers will indeed have cause for complaint, because the reputation that the latter have earned for constructing good boilers of sound material and workmanship must be sacrificed if they compete with the unrestricted efforts of eastern manufacturers.

It is desirable, in a controversy of this kind, to limit the discussion to the engineering standpoint and to keep out all commercial aspects, as far as possible. Unfortunately, this desirable condition is not always attainable, and arguments of a commercial nature are introduced to prove that the code has been beneficial to California.

The largest manufacturer of boilers in the state, and the one having the most modern and up-to-date shop, attributes the success of his boiler manufacturing business almost entirely to the adoption of this code. It is an undeniable fact that more boilers have been built in California in the last three years than were built in a period of over ten years immediately preceding.

Accurately speaking, the boiler code of the American Society of Mechanical Engineers is nothing more nor less than an engineering specification, stipulating the quality of materials to be used in boiler construction, the broad general principles to be followed in construction and setting forth in simple language the mathematics that enter into the calculations necessary to the proper design of any type of boiler. If these facts are thoroughly understood, it is felt that the objections to the code will be entirely removed.

OPINIONS OF THE A.S.M.E. CODE.

United States Bureau of Standards.

"The Bureau regards the Boiler Code of the American Society of Mechanical Engineers as the most authoritative publication on the subject of safety in the construction and operation of steam boilers, that is available.

"The Bureau of Standards is very glad to endorse the work of the American Society of Mechanical Engineers in this field and we hope that these standards will become national throughout the country."

W. W. Hanscom, Chairman, San Francisco Section, A.S.M.E.:

"It has long been recognized that standardization in manufacturing is a most important factor, especially where the products are to be of national use and are liable from the nature of their application to be dangerous to life and property if neglected or improperly handled. I know of no product to which this statement will apply with more force than in the case of steam boilers, for in their use forces are constantly at work to decrease the original strength and factor of safety. In the manufacture of boilers, like every other product, there are some who take advantage of every opportunity to reduce cost, not always with the idea of maintaining safety in use, but generally with the idea of increasing profit at the expense of the purchaser.

"In summing up what has been previously written, it would be evident that there is sufficient and immediate demand for standard rules regulating the construction, installation and operation of steam boilers. That these rules should be nationally adopted and enforced so that conditions will be uniform throughout the country; that proper provision should be made for the depreciation and deterioration continually taking place in the boiler and on it, to allow for the misuse and the invisible and visible changes taking place in the materials of the boilers and also for the utter impossibility of ever reaching 100% efficiency in the manufacture of materials, the working of them into commercial shape, or in the use of the finished product in the service of man.

"As the fundamental basis upon which the Code has been formulated is safety, one of the principal, if not the principal, factors is undoubtedly that which determines the allowable pressure at which a boiler should be operated."

Charles Edward Lucke, Professor of Mechanical Engineering, Columbia University:

"You may, therefore, assure everybody that no better basis exists, nor is there any prospect of securing a better basis for a safe procedure regarding boiler construction and maintenance than is now available in the A.S.M.E. Boiler Code. * * * Just how to make a boiler safe and how to prescribe rules insuring its safety, the Code sets forth that it was framed by people who knew, and it would be difficult and very likely impossible to find any group of people better able to do what has been done."

S. F. Jeter, Chief Engineer, Hartford Steam Boiler Inspection and Insurance Company:

"As an engineer who is interested first, last and always in the steam users' viewpoint relating to questions regarding rules and regulations to govern boiler operation, I can not see how any organization is better fitted to draft safety rules than the American Society of Mechanical Engineers.

"The rules were adopted only after the utmost publicity and an invitation to every one interested to criticise the proposed rules before they were actually made a part of the Code.

"As a final check against the adoption of any rule that might react against the steam user or was not consistent with good practice, and as an aid in securing uniformity, a Conference Committee to the Code Committee was appointed by the Society, this Conference Committee being composed of the chief inspectors of all the states having adopted the Code."

F. R. Low, Editor, "Power":

"The specifications are no more exigeant than is necessary to insure safety, and any boiler shop can build to conform to them. The contention on the part of those who would prefer to take a chance upon a boiler that was not so safe, that the Code has been formulated by the big boiler builders so as to put the small builders at a disadvantage, is natural but cheap and fatuous."

John A. Stevens, Chairman, Boiler Code Committee, A.S.M.E.:

"The A.S.M.E. Code is and was certainly at the time of the convention the most complete code in existence for the safe and commercial construction of boilers in the United States of America, as evidenced by the number of states and municipalities which have since made this Code a law on their statute books."

S. J. Williams, Secretary-Chief Engineer, National Safety Council:

"I have no hesitation in saying that the A.S.M.E. Boiler Code is by far the best code in existence and is so recognized by a great majority of boiler owners and users, government authorities, and engineers. This Code was formulated by a joint committee under the auspices of the American Society of Mechanical Engineers. This society is entirely free from any selfish interest in the matter, its only desire being to standardize boilers in the interest of safety, and, secondarily, of economy."

H. W. Mowery, President, American Society of Safety Engineers:

"The A.S.M.E. Code is a Safety Code. In the original statement of the Committee to the Council of the A.S.M.E., it stated: 'The primary hope of these rules is to secure safe boilers.'"

W. F. Durand, Stanford University:

"From such contact as I have had with the Code, I have been impressed with the fact that it seemed designed throughout to promote safety in industrial establishments, and to hold up to boiler makers and users a high standard of construction and installation.

"The ideal before the Society (A.S.M.E) in promulgating this Code was to place before the builders and users of boilers a standard code, reasonable in its requirements, undeniably safe and which might ultimately become the universally recognized standard throughout the country."

J. C. McCabe, Chief Inspector, State of Michigan:

"The essential feature in the adoption of the A.S.M.E. Boiler Code is that under a code of recognized standing, having the authority of the greatest engineering society in the world as its sponsor, it removes any reasonable doubt as to the safety of a boiler built under its rules.

"I have been in constant touch with the development of the A.S.M.E. Boiler Code, and the only criticism which I can make against the Boiler Code Committee is that they are endeavoring to make the provisions of the Code as reasonable as possible, and occasionally they overstep what would be considered, in my opinion at least, good engineering practice, all with the best intent of making the Code workable, popular and effective.

"It would certainly be a step in the wrong direction if the authorities recede from their endorsement and use of the A.S.M.E. Code in the State of California."

Chas. T. Main, Engineer, Boston:

"When the Boiler Code Committee of the American Society of Mechanical Engineers was set up, the members were very carefully selected to represent equally the manufacturers, users, and designers, and that proportion of members has been carefully maintained since that time, so that no one interest has ever dominated the committee in the past, nor does in the present."

BOILER SAFETY.

By R. L. Hemingway, Chief Boiler Inspector.

The Workmen's Compensation, Insurance and Safety Act, effective January 1, 1914, gives to the Industrial Accident Commission authority to inspect all places of employment, to require reasonable safety in such places of employment, and for the purpose of determining what constitutes reasonable safety, the act specifically gives the Commission power to set safety standards and to establish such rules and regulations as may be deemed necessary to furnish this modicum of reasonable safety. These powers are very clearly set forth in sections 51 to 72 of the above-mentioned act.

Since the statute imposes these responsibilities upon the Commission, it naturally proceeded to establish safety standards and regulations to to meet the requirements of the various industries. It will be very generally admitted that no set of safety standards could be complete unless it contained rules and regulations governing the operation of steam boilers, for the very obvious reason that a boiler, even though operating at low pressure, contains all the potentialities of a catastrophe, unless the pressure it carries is regulated to within safe limits and unless the appliances for controlling that pressure are maintained in proper working order, under the supervision and care of men intelligent enough to realize the responsibility that they assume when taking charge of a steam boiler.

In the natural sequence of events, the drafting of safety orders to cover boilers that were already installed in the state was first undertaken and this led to the adoption of rules governing the construction and installation of new boilers in the future.

The formulation of any one set of safety orders is a matter involving views of widely separated interests and in consequence of this the Commission decided to adopt the plan of appointing committees who would represent these numerous interests, and thus a set of safety orders would be formulated which would obtain the maximum of safety with the least hardship to all parties concerned. Thus, when it came to drafting Boiler Safety Orders, interests were invited to send representatives who would sit on the committee and have a voice in all its deliberations. To further widen the scope of the work, two such representative committees were convened, one in San Francisco and the other in Los Angeles, and in this manner those having the greatest interests at stake, including employers and employees, were fully represented. These committees met over a period of many months during 1915 and 1916 and, as a result of their labors, the Boiler Safety Orders comprising rules for existing installations and a code for the construction and installation of new boilers were presented at public hearings in the fall of 1916. As is now well known, the committee decided to adopt the boiler code of the American Society of Mechanical Engineers, which code was published in the year 1914, after several years of earnest work on the part of some of the foremost engineers in America. Two of these public hearings were held, one in San Francisco and one in Los Angeles. Both meetings were largely attended and many points were freely discussed although it was remarkable that but few changes were even requested when explanation was given of the why or wherefore in each case. In no case was the change or amendment of more than minor import.

The need of such a standard code was becoming more and more obvious, as individual states in their desire for progress saw the necessity of having some regulation governing the construction of new boilers. Massachusetts, the pioneer state in this respect, had a code of its own and when Ohio, two or three years later, decided to adopt a code, it was found that there were some features in the Massachusetts code that did not appeal to the engineers in Ohio. When Michigan followed, a difference of opinion arose between the Michigan engineers and those in Ohio and Massachusetts, and so it went all down the line, until the boiler manufacturer was almost at his wits' end to know how to comply with the various state codes, which, owing to their strict enforcement, would not permit an Ohio standard boiler to go into Massachusetts or a Michigan standard boiler to go into Ohio.

It is easy to see what tremendous financial hardship this lack of uniformity was imposing on the industries of the country, and also since every boiler, practically, that was built in the shops required a special specification, the cost to the user was always higher than it need be. Conditions were rapidly leading to confusion when about 1907 or 1908, the president of the American Society of Mechanical Engineers appointed a boiler code committee whose special object was to draft a uniform code for the construction and installation of stationary boilers. The original committee consisted of eight members and they in turn appointed an advisory committee to assist them in the draft of the code. The advisory committee represented consulting engineers, manufacturers of various types of boilers and boiler materials, boiler insurance companies, agricultural boiler manufacturers, boiler users and the American Society of Mechanical Engineers.

This code was finally approved by the Council of the American Society of Mechanical Engineers in February, 1915, and is known as the 1914 edition of the A.S.M.E. code. The committee in submitting it recommended that a permanent revision committee be appointed to undertake such modification or revision as might be necessary, as the state of the art of boiler construction advanced, and that such committee should hold meetings at least once in two years, at which time all interested parties might be heard. This, then, is the code which the Boiler Safety Orders committee of California approved and recommended to the Industrial Accident Commission for adoption. There was no objection raised to the adoption of this code at either public hearing on Boiler Safety Orders in the fall of 1916. The Commission approved this recommendation and the code became effective on January 1, 1917, together with the Boiler Safety Orders relating to existing installation, which the committee appointed by the Commission had drafted.

During 1919 it was deemed advisable to undertake a revision of the Boiler Safety Orders, less with the idea of changing the requirements in any respect than with the idea of introducing certain minor matters which the previous two years' experience had shown would increase boiler safety by making certain orders more specific and incidentally would be advantageous and more convenient for inspectors who had to apply these rules. The only serious change contemplated related to the rules governing second-hand boilers of lap-seam construction, and also the adoption of the 1918 edition of the A.S.M.E. code, as revised by the code committee in lieu of the 1914 code. In this manner it was thought that the Boiler Safety Orders relating to both existing installations and new installations would be brought up to date. Certain interests in the state raised objections to some of the features contained in the Boiler Safety Orders, principally with reference to the factors of safety for lap-seam boilers of existing installations and the factors of safety for second-hand lap-seam boilers.

In prosecuting their case, these objectors brought in representatives of labor who, unfortunately, formed an entirely erroneous impression of what the A.S.M.E. code is or what it purports to do, the controversy culminating in a bill being introduced into the legislature, known as Assembly Bill 1300, which bill was designed to repeal the Boiler Inspection Act, known as chapter 202 of the laws of 1917 and thus take from the Industrial Accident Commission the authority to require permits for boiler operation, to charge inspection fees and to require that all boiler inspectors hold certificates of competency before being allowed to inspect boilers. Some of the proponents of the repealing measure had a mistaken impression that the A.S.M.E. code would be eliminated in California by the enactment of Assembly Bill 1300. The fact is that only by either revising the Boiler Safety Orders or amending the Workmen's Compensation, Insurance and Safety Act would it be possible to eliminate the A.S.M.E. code.

In protesting against the adoption of the A.S.M.E. code in California, the claim was frequently made that this code would militate against local builders and would favor Eastern manufacturers, though in what way was never made even approximately clear. An illustrating incident tending to controvert this argument occurred in May, 1921, when a state boiler inspector found a code boiler that had been built in California on a

Brown hoist. The owners are a concern representing Eastern manufacturers among other lines, and on asking why an Eastern built boiler had not been used to replace the old boiler (also built in the East), the inspector was told the California built boiler cost thirty per cent less than the price quoted by the original manufacturer. The records in the offices of the Industrial Accident Commission show conclusively that more boilers have been constructed in California in the past three years than were manufactured in the state in the ten years immediately preceding 1918. This does not take into account boilers built for marine service. In all, approximately 400 California standard boilers have been built in California since January 1, 1918.

As a matter of fact, the A.S.M.E. code was designed and formulated with a threefold object, viz: (1) Primarily to secure safe boilers; (2) to safeguard the interests of all concerned, especially manufacturers of boilers, whether in California or elsewhere, by making requirements which were such that they would not entail undue hardship by departing too widely from present practice; (3) the furnishing of a uniform code with which any manufacturer, whether east, west, north or south, could readily comply.

The thought in the minds of those who objected to the code seemed to be that California should draft a code of her own, which would incorporate certain features and rules that would favor local manufacturers and enable them more readily to compete with Eastern manufacturers. It is self-evident that these men failed to realize the enormous amount of labor and money required before such a code could be prepared. Furthermore, it is very unlikely that such a local code would be as good as the A.S.M.E. code, for the reason that there would not be available the engineering talent that was available for the latter.

Mr. S. F. Jeter, Chief Engineer of the Hartford Steam Boiler Inspection and Insurance Company, writing on this subject, in the July, 1916, issue of *The Locomotive* says:

"If the need for adopting the same set of rules in each state where laws are proposed to govern the construction of boilers is considered advisable—and it does not seem possible that the least thought on the subject can lead to any other conclusion from the steam users' standpoint—then the American Society of Mechanical Engineers' Boiler Code is practically the only set of rules available for such use. All disputed points in connection with these rules have been fought out with the parties interested and a conclusion reached; and any attempt at selecting a different set of rules would mean that the same ground would have to be fought over again. It is more than likely that in the end practically the same conclusions would be reached, if a like amount of care was used, as in the preparation of the Boiler Code."

There can be no question of the wisdom in California adopting this code when one considers the fact that nineteen states and twenty-four municipalities have already adopted it, and it has been added to the textbooks in many of our most prominent engineering colleges and schools. Once more quoting Mr. Jeter, from the same source:

"It would, therefore, appear that the American Society of Mechanical Engineers' Boiler Code should be superior to any set of rules that has been put out or may be put out by a State Board delegated to perform a similar duty."

In his conclusion, Mr. Jeter says:

"Since the steam user is the one who ultimately will derive the greatest benefit by the attainment of the desired end, in that he will secure the greatest return for his investment, in boiler equipment, it would seem only right that, as the project has been so auspiciously launched, the steam users should lend their full cooperation in carrying the work to a complete and successful finish."

Reverting to the statement already made, that the only change of note in the revised Boiler Safety Orders, as they relate to existing installations, was in connection with the factor of safety for second-hand boilers of lap-seam construction the charge was frequently made that the revision of the Orders was along lines that would call for drastic reduction in working pressures on lap-seam boilers and even the proposed new rules would condemn all lap-seam boilers in California. No statement could possibly have been more remote from the actual facts, since the revision committee has never even contemplated changing the factors of safety on any boilers except the second-hand lap-seam boilers, either by upward or downward revision.

Since the Boiler Safety Orders went into effect on January 1, 1917, the Boiler Division of the Department of Safety has inspected approximately 4,049 boilers, of which number the records show only 46 were actually condemned as being unfit for further service. Many of these might still have been of some use as heating boilers, had there been any call for them. At prevailing junk prices, however, they were worth more to their owners as scrap. There were, of course, numerous cases where pressures were reduced to comply with the rules, but these were in no way to be regarded as condemnations, because under the Boiler Safety Orders the boilers could still be operated under a factor of safety of 5½ as second-hand boilers after proper inspection.

The claim was frequently made that these factors of safety for lap-seam boilers of existing installation were unreasonable and that they inflicted serious hardships on the owners of boilers of that type. It is, however, extremely difficult for the initiated, or indeed for any one accepting the logic of engineering, to see how such a claim could be made, when it is considered that the least factor of safety that may be used on a brand new code boiler is 5, and the Boiler Safety Orders do not call for any higher minimum factor of safety than 5 on a boiler of lap-seam construction, existing installation, regardless of age or service, provided in the opinion of an inspector its condition warrants continuing this factor of safety.

One can hardly believe that the proponents of lower factors of safety would claim that a boiler is less safe in Massachusetts or Ohio than in California, since in those two states operators of boilers are required to have licensed engineers and firemen in charge, and yet the factors of safety in Massachusetts vary from 5 as a minimum up to ten years of age, 5½ up to fifteen years of age, and 5¾ up to twenty years of age, with 6 for boilers over twenty years of age, there being no exceptions and no provisions. In other words, if a lap seam boiler in Massachusetts has passed its twentieth anniversary and the pressure given by a factor of safety of 6 will not perform the work required of it, that boiler must automatically be thrown out, regardless of its condition, no provision even being made to allow for part time use. The following table illustrates the factors of safety on boilers of longitudinal lap seam construction in some of the states that have boiler rules in effect.

FACTORS OF SAFETY.

	Existing installation							New installation
	Longitudinal lap seam					Butt strap construc.ion	Second hand longit. lap seam	
	Up to 5 yrs.	Over 5 yrs.	Over 10 yrs.	Over 15 yrs.	Over 20 yrs.			
1. 1917 California[d]	4¼	4½	4¾	5	5½[a]	4 [h]	5½	A.S.M.E. Code 5
2. 1916 Ohio[ce]	4½	4½	4½	4½	4½	8 [g]	4½	A.S.M.E. Code 5
3. 1919 Missouri	4½	4½	4½	4½	4½[f]	4½	5½	A.S.M.E. Code 5
4. 1916 Pennsylvania	4½	4½	4½	4½	[f]	4½	5½	A.S.M.E. Code 5
5. 1920 New York[b]	4¼	4½	4¾	5	5½[a]	4 [j]	5½	A.S.M.E. Code 5
6. 1918 New Jersey[be]	4¼	4½	4¾	5	5½[a]	4 [i]	5½	A.S.M.E. Code 5
7. 1920 Wisconsin	4½	4½	4½	4½	4½	4½	5½	A.S.M.E. Code 5
8. 1910 City of Detroit[e]	5	5	5½	5¾	6	4½	8 [g]	A.S.M.E. Code 5
9. 1919 Massachusetts[e]	5	5	5½	5¾	6	4½	8 [g]	Mass. Boiler Rules 5
10. 1913 British Columbia	6	6	6	6	6	[k]	6.3	Provincial Law k

[a]Factor of safety of 5 allowed if conditions warrant.
[b]Riveted joints to be uncovered for hydrostatic test if factor of safety 5 is continued over 20 years of age.
[c]Factor of safety shall be increased if the conditions and safety of the boiler demand it.
[d]Allowance in age made for part time use.
[e]No allowance in age made for part time use.
[f]Pressure cut to 50 lbs. except that factor of safety 4½ may be continued to 25 years if condition of boiler warrants it.
[g]For shells over 36 inches diameter factor of safety 6 if 36 inches or less in diameter.
[h]After Jan. 1, 1922, the minimum factor of safety is 4½.
[i]Over 20 years of age the minimum factor of safety is 4¼.
[j]Over 10 years of age the minimum factor of safety is 4½.
[k]The basic factor of safety is 4, to which are added penalties for conditions and bad practices during construction.

In the face of the foregoing, it is difficult to understand the reasoning that actuates men in asking for a reduction in the factors of safety that are stipulated in the Boiler Safety Orders of January 1, 1917.

The question may be asked, "Why is it necessary to discuss at such length the factors of safety on lap seam boilers?" The answer is found in the pages of engineering magazines, such as *Power* and *The Boiler-maker,* which report boiler explosions, together with the details of the causes that have been determined upon investigation.

History has shown that the boiler with longitudinal lap seams has a disagreeable propensity for developing a hidden crack which seldom gives warning of its presence. Furthermore, when the failure occurs, it comes with a suddenness and violence that results in havoc and destruction all around. Such a case occurred in the Grover Shoe Company, at Brockton, Massachusetts, when 58 lives were lost and 117 people were injured, the property loss amounting to over $250,000. In another part of this bulletin will be found descriptions of a more recent boiler explosion that was caused by a lap-seam crack.

The Fidelity and Casualty Company of New York

ROBT. J. HILLAS, President

92 Liberty Street
New York

D. C. HARVEY,
Superintendent of Inspections

May 31, 1921.

DCH.MAW

CIRCULAR LETTER NO. 151.

ANSWER TO LETTER OF

TO ALL BOILER AND FLY-WHEEL INSPECTORS:

HORIZONTAL TUBULAR BOILERS.

LAP SEAM TYPE OF CONSTRUCTION.

HORIZONTAL TUBULAR BOILERS
CONSTRUCTED WITH LONGITUDINAL LAP SEAMS
EXTENDING FROM HEAD TO HEAD
AS IN CASE OF ONE SHEET ON THE BOTTOM
AND ONE SHEET ON THE TOP BOILERS.

. . . . . .

In making inspections of Horizontal Tubular boilers of the lap seam type of construction twenty years or more old, each inspection report, other than data report, should have written on it by the inspector the following statement: THIS BOILER IS OF THE LAP SEAM TYPE AND IS____________YEARS OLD.

The object of this is so that in sending out the report, attention may be called to the age and construction of the boiler. It does not necessarily follow it is considered the pressure should be reduced or the boiler replaced by one of modern design. The result of the inspection will show what is required in this respect.

It is important the assured should be advised of the situation and the reasons for discarding boilers of this type so that when the proper time arrives to reduce the pressure or call for the boiler to be replaced, they can not say the matter has not been brought to their attention before we advised taking action.

Explain to the assured the weakness of the construction and point out disastrous explosions have resulted from the continued operation of such boilers. Explain to them how a piece of metal will, after repeated bending, eventually break. How a similar action takes place at the lap longitudinal seams due to the distortion from the true circle.

It is important you see the above is done.

Hydrostatic tests: In the case of boilers of the lap seam type of construction that have reached the age of 20 years, arrangements should be made for applying a hydrostatic test at the time of the internal inspections. In case there are no facilities at the plant for applying such a test, then draw attention to this fact on the inspection report.

Horizontal tubular boilers constructed with longitudinal lap seams extending from head to head: All boilers of this type are of obsolete construction and should be looked on with suspicion and the inspections should be most rigid. When boilers of this type have reached the age of twenty (20) years, they should be replaced and under no circumstances should they be continued in service unless subjected to a hydrostatic test of 50 per cent in excess of the pressure at which they are to be operated, with the brickwork removed to expose the longitudinal seams.

In making inspections of this type of boiler, arrangements should be made with the assured to apply the hydrostatic test and to uncover the longitudinal seams when this is done. If the test and inspection show there is no evidence of lap seam cracks or other weakness, the boiler may be continued in service for a limited period, in order to give the assured an opportunity to procure a new one. The matter should be followed up closely until the boiler has been replaced.

The following factors of safety should be used in determining the allowable pressures:

10 to 15 years	factor 5
15 to 20 years	factor 6
20 years and over	factor 8

In making your inspections if you find the factors of safety as given above will reduce the pressure to a point that would make the boiler useless, then explain to the assured, providing the age and condition of the boiler in your opinion warrants, that at your next inspection, it will be necessary to reduce the pressure to correspond with the factors of safety, as stated and in this manner give them ample warning in advance of what will be done and so they may have time in which to make change that may be required to meet the conditions.

It is important you explain to the assured the weakness of the construction of the boilers, pointing out the longitudinal seams are continuous and are not broken as in the case of boilers built in ring courses and that the absence of girth seams tends to further weaken the structure.

The instructions, as outlined above, must be rigidly adhered to and we hold the inspector responsible for seeing this is done.

Please acknowledge receipt of this letter.

Yours truly,

D. C. Harvey, Superintendent.

HOW SAFE IS A USED LAP-SEAM BOILER?*

The question of the factor of safety to be used in determining safe working pressures for boilers other than those built to comply with the A.S.M.E. code and which have been for some years in operation, has been one fraught with considerable discussion in recent weeks in the West. It seems that the boiler revision committee of the Industrial Accident Commission of California, holding hearings in San Francisco, proposes a factor of safety increasing with the actual use of the boiler. Some serious objections have been made to these factors by users of boilers and by second-hand dealers. It would appear evident that an increasing factor should be applied from year to year in proportion to the length of service of the boiler, and it is to be hoped that the objections will be cleared away in a friendly manner and the entire code put into operation at the earliest date possible, in order that this commonwealth may stand in its usual position, that of front rank in matters of progress towards safety and accident prevention.

Lap-seam construction has come in for the greatest amount of discussion. The attitude of the committee appears to be fair to the owners of lap-seam boilers within the state of California in that it proposes no change in safety factors on existing installations from those in force since January 1, 1917. These boilers were purchased and installed in good faith, under the conditions of safety then generally known. But the committee seems to be unwilling to permit a prospective purchaser to buy and change the location of a lap-seam boiler which has already been in use, without applying a factor of safety which it believes reasonably safe for this type of construction. Eventually, the committee feels, the lap-seam construction must be displaced by a design that is free from the inherent defect known to boiler experts as "the typical lap-seam crack."

"Second-hand stationary boilers within the state of California on October 1, 1920, by which is meant boilers where both ownership and location are changed, shall, if of lap-seam construction, have a factor of safety of at least six," says Sec. 381, (a) of the proposed revision. Virtually identical installations in other communities show that the states of New York, New Jersey, and Pennsylvania require the same factor of at least six, while Ohio, Massachusetts and the city of Detroit will permit nothing under eight, except for boilers thirty-six inches in diameter or under, when the factor of safety is at least six. It would seem then that a factor of six could well stand, and that the objections urged against its adoption as being too high and as leading to prohibitive boiler practice should be overruled.

BOILER CODE—THE A.S.M.E.*

Unquestionably one of the most constructive pieces of engineering work ever undertaken by an engineering society is that of the boiler code of the American Society of Mechanical Engineers. This code goes into great detail as to how boilers should be properly constructed, the factors of safety involved in designing the boiler and many other helpful and valuable rules for proper design and installation. Since the code was first promulgated in 1914, seventeen states and several cities, including

*Editorial, *Journal of Electricity,* October 1, 1920.

Philadelphia, Detroit and Seattle, have adopted it as the official legal document for state inspection work. California has adopted the A.S.M.E. 1914 code as from January 1, 1917, and the revised boiler safety orders propose to adopt the 1918 code. The California Industrial Accident Commission is to be congratulated on this forward step toward boiler safety.

METHODS OF JOINING BOILER SEAMS.*

The boiler is unquestionably the most prolific source of danger and disaster in steam plant operation. The history of steam generation for power purposes furnishes ample demonstration of what this magazine of stored-up energy can accomplish, in the way of general destructiveness, when once it breaks out of bounds. An almost interminable list of disastrous experiences with defective and neglected boilers has made us thoroughly alive to the potentiality of this detail of power plant equipment as the instrument of devastation and ruin; and as a result, the boiler has always been the theme of a vast amount of discussion and agitation, looking to general improvement along the lines of safe design, construction and operation. Indeed, it is the case in many localities and states that legislative enactment is resorted to in the endeavor to safeguard life and property from the menace of dangerous boiler plants, by compelling vigilant care in the selection of correct designs and the best obtainable materials, as well as in the items of good workmanship and intelligent operating conditions.

The Lap-Seam Boiler.

The type of boiler that has furnished by far the greatest number of explosions during recent years, is the horizontal tubular boiler, with boiler-riveted lap-joints, longitudinal seams and *as a general rule, it has been found that when one of these boilers explodes the initial rupture occurs in one of the aforesaid seams.*

While there is a constantly growing sentiment among practical engineers antagonistic to the lap-riveted longitudinal seam and notwithstanding likewise that boilers with this type of seam are *being gradually legislated out of existence in some states,* in favor of boilers having the mechanically correct butt-and-strap joined seams, still the manufacture and use of boilers of this type continues to go on unrestricted in most parts of the United States, and it appears highly probable from present indications that *we will not see the end of this mechanical monstrosity for some years to come.* It is, therefore, appropriate that in this discussion of boiler seams, we should give priority of attention to this oldest and generally most prevalent, *as well as most reprehensible form of joint.*

The Lap-Riveted Longitudinal Seam Inherently Defective.

To begin, let us first investigate the lap joint as used in longitudinal seams, with a view of finding out wherein it is really deficient, for a superficial glance at the proposition would indicate that so far as the ordinary stresses of operation are concerned, this type of joint should be just as safe and reliable as any other; and such is the case, for by correctly proportioning the diameter and pitch of the rivets and the

*Reprinted from the January, 1921, issue of *International Steam Engineer.*

thickness of the plate, to the tensile, shearing and compressive stresses involved, a joint of this kind may be designed which will give a percentage of the strength of the solid plate ample for all ordinary purposes.

The objection to the lap-joint construction is not based, however, upon any deficiency of strength when new, *but upon the deterioration that immediately sets in, the very moment the boiler first goes into service,* by reason of the *bending stress in the net section of plate* between the rivets in the outer row.

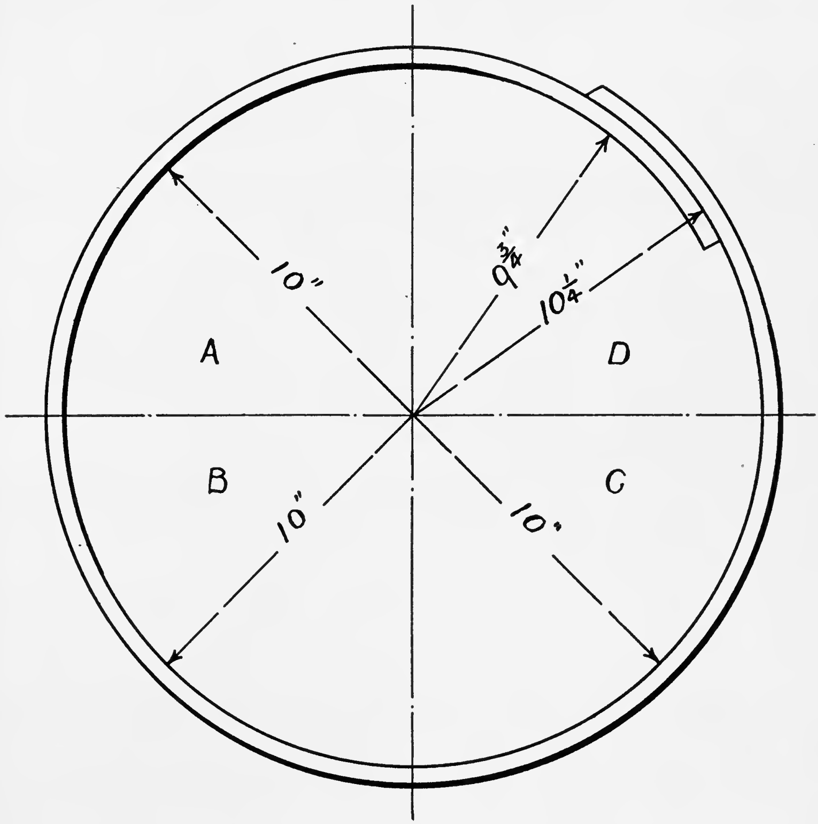

Fig. 1.

To make this point clear, let us refer to Figure One, which represents a cross-section through a shell made of boiler plate one-half inch thick, and rolled to a nominal internal radius of ten inches.

Now if this shell plate, when flattened out, had been sheared to the exact width necessary to form the envelope of a cylinder twenty inches in diameter, and had then been rolled to conform to a 20-inch circle, it would have met or butted edge to edge, and the internal radius would have been exactly ten inches, no matter in what direction it might have been measured from the axis of the shell.

But in order to make a lap joint for a shell of ten inches radius, as shown in the illustration, it is necessary to cut the sheet wider than the length of the circumference of a 20-inch circle, and so, when the plate is rolled to a 10-inch radius and the edges slipped by each other to form the joint, any radius in the segments A, B, C will be ten inches, or an extremely close approximation thereto; but at the same time the radii in the lower half of segment D will gradually increase toward the joint, while the radii in the upper half will decrease as they approach the joint, the net result being that a radial line measured to a point directly beneath the joint will approximate very close to ten and one-fourth inches, while the corresponding radial line above the joint will be nine and three-fourths inches or thereabouts, the resilience of the plate being assumed as uniform throughout.

Now we know that the energy of an internal pressure against the wall of a cylindrical vessel is manifested in the *effort to maintain the true circular form* and *round out any indentations or irregularities tending* to impair the cylindrical contour of the vessel. Consequently, if a liquid or fluid pressure were applied to the inner surface of our shell in Figure One, through the agency of water, air, steam or otherwise, its energy would immediately be exerted in an effort to make all points in the surface of the shell conform to the same distance from the axis, and the direct effect of this straining after perfect symmetry, would be to *induce* a flexure in the seam by the lengthening of the radii above the joint and the shortening of those below. This bending stress would obviously expend itself in straining the inner lap through the section of metal between the rivet holes in the upper row, and the outer lap through the section of metal between the rivet holes in the lower row.

It might reasonably appear from cursory and superficial study of the phenomenon that the strain involved, being of such inconsiderable magnitude, could really have no deleterious effect on boiler plate possessing the highly malleable and ductile properties required of first-class material; and such would undoubtedly be the case, if the bending of the plate in the places indicated would occur only at comparatively long intervals in the life of the boiler, as for instance, at the beginning and close of a period of actual service.

This advantageous condition, however, *can not possibly be realized in boiler practice,* for the maintenance of a constant steam pressure is something highly impracticable, if not to say impossible of accomplishment with ordinary method of operation, and the aforesaid flexure occurs with *every change of pressure, howsoever slight.* The very moment a diminution of pressure occurs, the resilience or springiness of the material instantly responds in an effort to restore the shell to its original shape, as shown in the illustration; but when the pressure again augments, no matter how trivial the increase, the edges of the plate again attempt to get into the line of strain; the pulsation being continuous, though insidious and never discernible to the eye. The alternate movement here described is frequently referred to as the "breathing" action of the boiler, since it is quite analogous to the regular expansion and contraction of the human torso under the stimulus of the respiratory nerves.

It is inevitable, therefore, that this constant bending to and fro should eventually *cause a series of cracks* to appear along the line of the rivets in either row, which are evidently the lines of least resistance, and that these cracks should go deeper at every flexure until the strength of the *plate is finally reduced to the point of rupture.* It is one of the mysteries of the phenomenon that these cracks invariably manifest themselves first in the inner surface of the outer lap, and never in the outer surface of the inner lap.

Thus it appears that opposition to the lap-seam boiler construction, springs not from any contention that such seams are unsafe for constant pressure, but from the evident impossibility of maintaining absolute uniformity of pressure in operation, and the consequent localization at the joint of the breathing movement which such lack of uniformity entails, as well as from the fact that the *resultant deterioration, being hidden between the lapped ends of the sheet, precludes all possibility of adequately estimating its extent without actually drawing out the rivets and taking the joint apart.*

One peculiar fact which stands out quite prominently in connection with the lap seam failures of the past is that wrought iron boilers seem to be practically immune from rupture of this kind. The theory has been advanced to account for this apparent anomaly—for anomalous it seems, since it is the popular idea that the use of steel as a boiler material reduces the liability to disaster from any inherent cause—is that the laminated structure of wrought iron, which, on general principles, is rather an objectionable feature than otherwise, acts as an obstacle to the progress of the deterioration, inasmuch as a crack starting in the outer stratum of metal will expend itself in getting through that stratum, so that an entirely new crack must be started in the next layer, and thus the impairment of the joint is arrested and delayed from time to time, *but is never entirely overcome. Steel, on account of its homogeneous texture, is deprived of this advantage.*

However, it may be accepted as a foregone conclusion deducible from the essential character of this latent imperfection in longitudinal lap seams, that any boiler having such seams, whether it be built of wrought iron or of steel, *if continued in service long enough, and spared the ravages of corrosion and other* sources of wear and tear, will eventually go to pieces by rupture of those seams as herein described.

APPLICATION OF INSIDE WELT STRAP TO OLD LAP-SEAM BOILERS.

By R. L. Hemingway, Chief Boiler Inspector.

There is probably not one of us that has not had carefully instilled into him the value of economy in all things, and while it is perfectly true that economy is the foundation of all business, it does seem that this trait can be overdone, at least in so far as it applies to the use of steam boilers. Apparently, too strict economy was the object of many concerns that put boilers in California in years gone by, for they demanded and obtained cheap boilers.

In order to obtain a cheap boiler, one of the first economies that the manufacturer makes is in the thickness of plate used in its construction, at the expense of the factor of safety. Another saving is accomplished by adopting the lap-seam construction for the longitudinal joints of the boilers.

When the Boiler Safety Orders became effective in California on January 1, 1917, there were a few instances in which the pressures on boilers had to be reduced, owing to the factor of safety that had to be applied, on account of the age of the boilers. This condition will recur year after year as age accumulates on these lap-seam boilers. Some owners, rather than discard their old equipment, on which the rules correctly require the working pressures to be reduced on account of age, have endeavored to find some means of extending the useful life of their old boilers, which still bear the earmarks of being good, at least on the surface. In doing this they have hit upon the old expedient of strengthening ordinary double-riveted lap-seam joints by the application of what is sometimes called the inside welt-strap joint, or the locomotive joint. The latter name comes from the not infrequent use of this type of joint in locomotive boilers. The joint itself consists of an ordinary double-riveted lap-joint, provided with an inside cover-plate, which is jogged so that it conforms to the curvature of the shell on both sides of the lap-joint. In addition to the rivets in the double-riveted lap-joint, there is also an outer row provided on each side, having twice the pitch of the rivets in the inner rows. This will be more readily understood by reference to figure one.

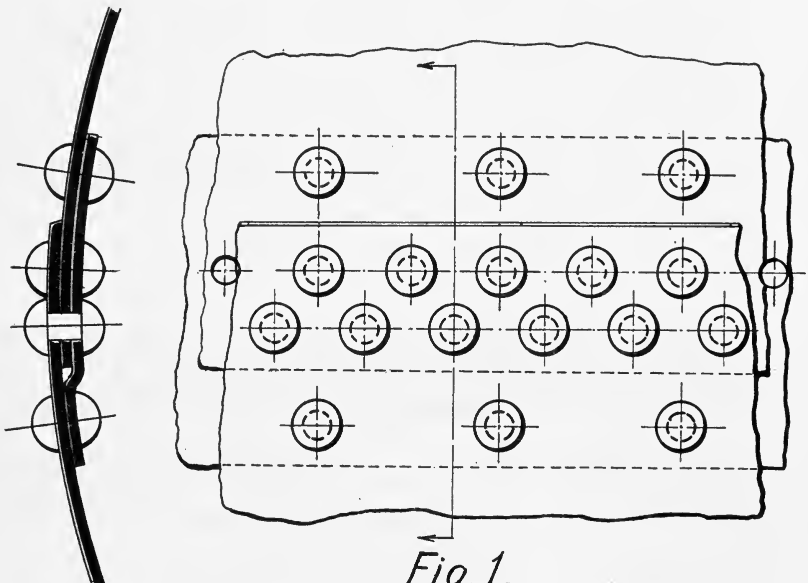

Fig. 1.

Sectional and plan view of lap joint with inside strap applied.

There is nothing new about this type of joint, as it has been known and used for many years, although it has never come into great popularity, owing to the fact that it is a mere subterfuge. In other words, while the application of an inside welt may increase the efficiency of the joint, the joint itself still remains a lap-joint, and as such it may be regarded as still subject to the development of the hidden cracks and to fatigue of the metal through constant flexure, owing to the breathing action of the boiler shell.

About 1887 some very exhaustive tests were made on this welt-strap type of joint at the Watertown Arsenal in New York, in order to determine if possible just what increase in efficiency this type of joint would furnish. The Government engineers, in preparing for the test, chose the very best possible material available at that time, the utmost care being taken in the preparation of the joints for the test. In addition to careful selection of material, the workmanship in the riveting was performed under the very best possible conditions. Notwithstanding these facts, the record of these tests shows that the average increase in efficiency did not amount to more than seven and one-half per cent above the efficiency of the ordinary double-riveted lap-joint to which no cover plate was applied.

This, then, is the expedient to which quite a number of California boiler owners and operators have recently resorted in order to restore the working pressures to or maintain working pressures at a point where they can still continue to operate their plants. The probabilities are that if this type of joint were used in the original construction of the boiler, there would be considerably less objection to it than now arises in applying it to boilers that have already seen some years of service.

It will be readily understood that one can not remove the rivets from a longitudinal lap-seam without seriously affecting the strength of the joint when other rivets are driven. Then, again, it is entirely problematical whether even the closest examination of the insides of a lap-joint would reveal the infinitesimally fine cracks which may be present in the material and which, although so fine, are still a pregnant source of danger.

To summarize, the locomotive, or inside welt-strap joint is no better than a lap-seam, beyond the fact that it is capable of a theoretically higher efficiency than is the ordinary double-riveted lap-joint. It is extremely doubtful whether this increase in efficiency does not constitute an increase in the hazard by reason of the fact that higher pressures are obtained through its use.

So far as known there is no law in any state which prohibits the use of this type of joint and probably there is no state in which its use has attained anything like the prevalence that it now seems to be gaining in California.

Lacking precedent for prohibition of its use, this type of joint will be accepted on conditions to be determined by the Industrial Accident Commission after the Boiler Safety Orders revisions committee shall have submitted its recommendations to the Commission. Under no consideration can the welt-strap type joint be recommended from an engineering standpoint, from the sandpoint of safety, or yet from the standpoint of economy. It may be trite to add at this time, but it is no less true, that safety and economy are inseparable in the long run.

THE SINGLE-SHEET LAP-SEAM BOILER.

By J. P. Morrison, Chief Inspector, Hartford Steam Boiler Insurance and Inspection Company.

[Reprinted, by permission, from April 26, 1921, issue of Power*.]

The single-sheet lap-seam boiler, so destructive of life and property, must go. An analysis of its weaknesses is evidenced by numerous explosions. It does not possess a sufficient margin of safety, is made of questionable material, is subject to injuries during the process of fabrication, is impossible of thorough inspection, and in operation is stressed beyond the safe limit by temperature difference, by lack of girth-seam support and by the unequal distribution of the weight of the boiler, contents and connections.

It is probable that no question of machine design has received more careful and intelligent consideration than has the design of the shell seams of steam boilers. Fairbairn's tests were conducted in 1838. W. Bertram conducted tests at the Woolwich Dock Yards in 1860. D. K. Clark discussed riveted seams in 1877. A lap-seam crack was reported in *The Locomotive,* issued in April, 1880, while that publication dealt at considerable length with the stresses occurring in lap seams. On April 17, 1891, J. M. Allen, who was then president of the Hartford Steam Boiler Inspection and Insurance Company, delivered a lecture at Sibley College, in which he gave a complete diagnosis of the various joints then in use, having particular reference to the triple-riveted butt-strap joint. This lecture was published and widely distributed, and the principles set forth are those upon which the calculations of riveted joints, encountered in modern practice, are based. In the early days of steel-plate manufacture the product was confined to sheets of small dimensions. As a consequence the boilers built in those days were composed of a number of courses, and each course, if the boiler was unusually large, would be made up of several sheets. It was not uncommon to encounter a boiler 14 feet in length and 48 inches in diameter made up of seven courses formed of four sheets each. But as the steel makers became able to produce larger plates, boilers were constructed of a lesser number of courses, each composed of fewer sheets. This appeared to be of considerable advantage in many ways, and when it became possible to produce plates of such size that only two were needed to form the shell plates of a boiler, they found a ready market. With the development in steel manufacturing the importance of the physical and chemical properties of the boiler plates was recognized, particular emphasis being placed on the advantages of great ductility even when obtained at a loss in ultimate tensile strength. Laminations found in steel plate had elicited some criticism, and there was a loud protest at the practice of some steel makers of shipping unbranded plates, for the boilermakers were beginning to realize the necessity of having the steel maker's brand appear on each sheet of the finished boiler. Boiler plates manufactured by both the open-hearth and Bessemer processes were used, and it was understood that the quality of the boiler plate depended more upon the grade of raw materials than upon the particular process.

*Cuts to illustrate this reprint were loaned by the editor of *Power,* 10th Avenue at 36th St., New York.

Difficulty that had been experienced by reason of girth-seam leakage, fire cracks and mud burns, all attributed to the sediment within the boiler accumulating against the girth-seam laps, gave added attraction to the idea of rolling one sheet to form the bottom half of the boiler. The upper half continued in some cases to be constructed of two or three plates, while in other cases one large plate only was used. This form of construction necessitated the use of a longitudinal seam on each side of the boiler extending from head to head, and was confined to shops having plate-bending rolls of sufficient length to pass a 16-ft. or 18-ft. sheet between housings.

It is worthy of note that this construction was criticised twenty-five or more years ago, and subsequent developments have proved the correctness of those who, while without sufficient facts at hand to justify outright condemnation of the single-sheet boiler, brought its weaknesses to public attention and withheld approval, citing the explosion of one boiler due to the single bottom sheet construction, and which resulted in the loss of two lives and an estimated property damage of $5,000. Those unacquainted with shop practice of the older days will hardly realize the possible damage done to a sheet during the process of fabrication of the boiler. The rivet holes were punched full size, except where special requirements were to be met, so the mill cracks started by the punching process were not removed. Few of the shops were equipped with a press to shape the ends of the sheet to the proper curvature. The work was done by placing the sheet over a rail or one of the bending rolls and sledging the edges, often stressing the questionable material beyond its elastic limit along the line of rivet holes in the second row, where the sheet had already been weakened by the reduction of the metal and by mill cracks, due to punching the rivet holes. To this were added the stresses set up when the poorly fitting joint was bolted up and later riveted. Usually, the joint was then sledged into shape for calking.

Fig. 1 indicates the change in shape of the ends of a plate when being formed over the roll by the use of the sledge. Fig. 2 illustrates the condition of the ends of the plate, after the rest of the plate has been rolled to the proper curvature. The ends, having been shaped by blows of the sledge, do not conform to the true curvature. That was also the era of the drift pin, when an unfair hole could be made fair, adding more stresses to the sheet along the line of rivet holes.

Even then the trend of the times was toward boilers of larger diameter. Since the size of the plates obtainable would not permit locating the head-to-head seams above the horizontal diameter, the seams of such a boiler were exposed to furnace temperatures, in addition to the stresses due to difference in temperature of the upper and the lower section of the boiler, the former being exposed to the atmosphere, while the latter was subjected to furnace heat as indicated in Fig. 4. The intensity of these stresses would vary considerably, but one authority has reported them as amounting to approximately 6,000 lb. per square inch.

The never-ending effort of the contained pressure to perform the impossible feat of rounding out the irregular surface existing at the lap seams produces the lap-seam crack, for which this joint is notorious. In Fig. 3, *x* and *z* indicate the development of such a crack, while Fig. 5

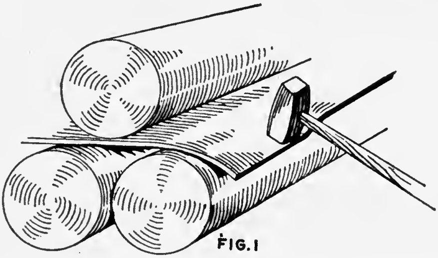

FIG. 1

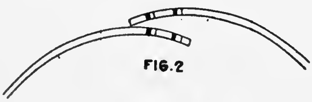

FIG. 2

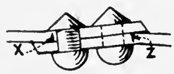

FIG. 3

Fig. 1. Forming end of plate over roll.
Fig. 2. Ends of plate to be sledged to shape.
Fig. 3. Lap seam stressed to failure.

shows a crack that developed in a plate in service. Furthermore, this lack of symmetry renders the plate along the line of greatest stresses susceptible to corrosive action, which would be intensified where there were three pairs of supporting brackets, as was the case with large boilers; and the settling of the furnace walls at the front or rear transferred the load, amounting to one-half the weight of the boiler and contents, onto the center bracket.

The strengthening effect of the girth seam has been the subject of considerable discussion. It is in principle quite the same as applying a hoop to the circumference of the boiler. This is evidenced in a number of instances when, upon the vessel being stressed beyond the elastic limit, the increase in circumference did not even extend to the girth seam, owing to the hoop effect of the seam. The fact that the explosion of a two- or three-course boiler, due to lap-seam failure, rarely results in a rupture extending across a girth seam should leave no need of further argument in favor of a construction embodying girth seams.

Before the double-strapped butt joint was universally adopted, a large number of lap-seam boilers, many of them of the single-sheet variety, were placed in operation. The majority of these boilers were intended for 100 lb. pressure, using a factor of safety of 4. *This factor has been generally recognized as inadequate even for boilers of superior construction, and could not be expected to be continued as satisfactory for lap-seam boilers after a few years of service and abuse.* (Italics ours.)

After considering the various factors having a direct influence on the safety of single-sheet boilers, it does not appear strange there have been so many violent explosions, with the loss of numerous lives and property damage approximating a million dollars in value. The facilities for investigating boiler explosions were probably not in keeping with the general industrial activities, but in the early days, when 80 to 100 lb. pressure was considered high, each explosion was more or less shrouded in mystery, and the theories advanced as to the cause were about as intricate and vague as could be imagined. The presence of a super-gas, the spheroidal state of the water, the geyser action of the water, superheated water, low water or no water, inflammable steam and the presence of a vacuum were theories, each of which had its following. The cause of the difficulty, the single-sheet lap-seam crack, was generally overlooked by investigators seeking to establish the correctness of their pet theory as to the force, or phenomena causing the destruction. A few engineers realized the influence of manufacture on boiler safety. Zera Colburn is quoted as stating in 1880, "All our knowledge of boiler explosions goes to show that in the majority of cases the actual explosion results from some defect, either original or produced, and either visible or concealed, in the material, workmanship or construction of the boiler."

There is no complete list of explosions of single-sheet boilers nor of the number that have been found to be unsafe and discarded from service, but the record available is sufficient to indicate clearly the unusual hazard attending the operation of boilers of that description. The condemnation of a boiler having a seam crack 14 feet in length was recorded in 1894,

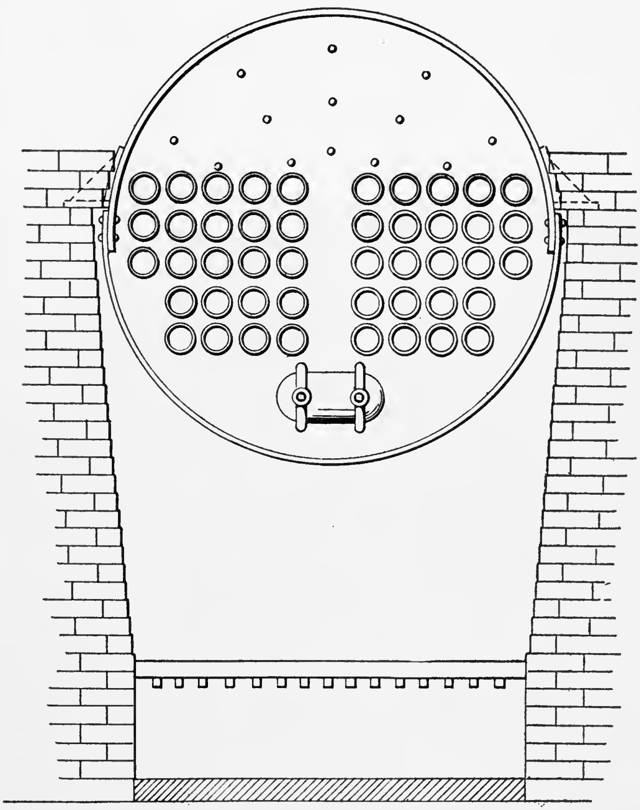

Fig. 4. Seams of single-sheet boiler inaccessible and exposed to furnace heat.

and on February 1, 1895, a boiler 66 inches in diameter by 16 feet long, containing 54 four-inch tubes, and constructed of steel plates 3/8 inches thick, forming a single course of the bottom of the boiler and three courses of the top, exploded in an electric light plant with disastrous results. One man is reported to have been killed, three others seriously injured, and the power plant totally wrecked. The line of failure followed the seam from the head two-thirds of the length of the boiler, from which point separation occurred, the girth seam being followed across the top of the boiler by one branch of the crack, and the other extending through the solid plate downward toward the rear. The boiler had three pairs of supporting lugs, and conditions indicated that the initial failure occurred under the middle lug.

The Rochester, N. Y., Brewery explosion followed in 1889, and caused the death of one man, as well as property damage estimated at $25,000. On November 26, 1901, a disastrous explosion of a 66-inch by

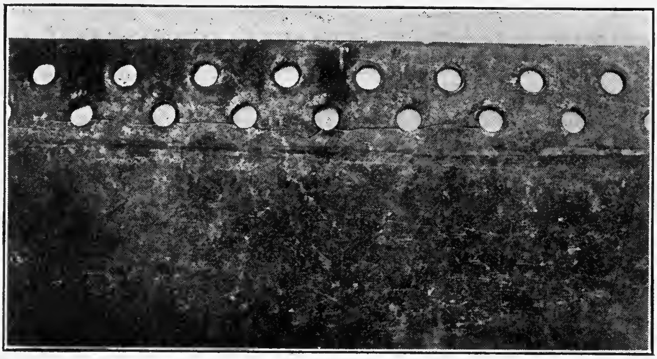

Fig. 5. A lap-joint crack.

16-foot boiler at the plant of the Penberthy Injector Works, Detroit, Mich., demolished a three-story brick building and cost the lives of thirty and seriously injured thirty-five others. The total property damage was estimated at $100,000. This boiler had seen but six or seven years of service and was understood to be in good condition. The line of failure followed the longitudinal seam on one side of the shell, substantially in a straight line from one head to the other.

Of a single-sheet boiler the next violent explosion of which record is available, occurred at the plant of the American Tin Plate Company, Canton, Ohio, on May 11, 1910, and was reviewed in the issue of *Power* of May 31, of that year. Then followed the Midvale, Ohio, explosion and the Shelton, Conn., explosion in 1911; the Pleasant Valley, Conn., explosion in 1915; the Athol, Md., explosion in 1916, and the Cross Run, Pa., explosion in 1917; all bearing the earmarks of lap-seam defects and occurring to single-sheet boilers, taking the usual toll in life and damaged property.

While the Fargo, Tex., explosion, occurring on October 1, 1914, was caused by a lap-joint failure of a single-sheet boiler, it differed materially from some of those previously mentioned, inasmuch as the boiler had been carefully examined by an expert inspector and pronounced unsafe to operate, his opinion being based on the corrosion which had attacked the longitudinal seam. These seams were not visible on account of their location below the upper tubes, but after cleaning those parts as thoroughly as possible, the inspector determined by his finger tips that there had been so much reduction in thickness that there was not sufficient strength to withstand the pressure. However, the owner placed the boiler in operation, and the second day thereafter it exploded, killing two men, injuring two others and wrecking the plant. Investigation developed the fact that the rupture had occurred in the outer sheet of the lap, that sheet forming the bottom half of the boiler, as is common with single-sheet construction, and followed a line parallel to the edge of the inner lap, extending from head to head through metal which, owing to corrosion, did not average ⅛ inch in thickness.

The accompanying photographs, Figs. 6 to 8, illustrate the damage done by the explosion of a single-sheet boiler, which resulted in the death of two workmen, and serious injury of two others, and the total

Fig. 6. Result from the explosion of a single-sheet boiler.

destruction of the plant. Fig. 6 gives a good idea of the general damage to the plant, and Fig. 7 is a close-up view of the boiler tubes and head. The boiler was said to have been about 24 years old, and its builder was unknown, as it had been used elsewhere and had changed owners a number of times. So far as could be learned, the boiler never had been subjected to an examination by anyone qualified to pass judgment in such matters. The double-riveted lap seams extended from the front head to the rear head on each side of the boiler. The means of support consisted of three pairs of castiron brackets resting on the furnace walls, one being between the dome and longitudinal seams, on either side of the boiler. The pressure carried at the time of the explosion was 100 lb., and it was probable the builder sold the boiler when new with the customary guarantee of that pressure, which would be permitted by a factor of safety of 4.

Some time previous to the accident leakage was observed at the longitudinal seam under one of the center support brackets. A boilermaker of questionable ability and experience patched the seam as indicated by the arrow in Fig. 8, apparently without giving thought to the cause of the difficulty, but riveting the patch at the boiler seam, and using patch bolts for securing the new seam. The boiler was continued in operation without further trouble until about a week before the explosion, when seam leakage was again observed. The mill superintendent and an employee are said to have drilled and threaded for ¾-inch capscrews, four holes along the seam where leakage had appeared. A soft patch consisting of a sheet of plow steel and a thin sheet of lead was secured to the boiler by means of capscrews and nuts, and the boiler was again placed in service.

The failure occurred in the sheet forming the lower part of the boiler, on a line coinciding with the edge of the inner lap, just about the same location as in the failure of the Fargo, Tex., boiler, and did not follow nor enter the rivet holes. It extended the entire length of the seam, as is customary with violent failure of this kind. The rivets in the head

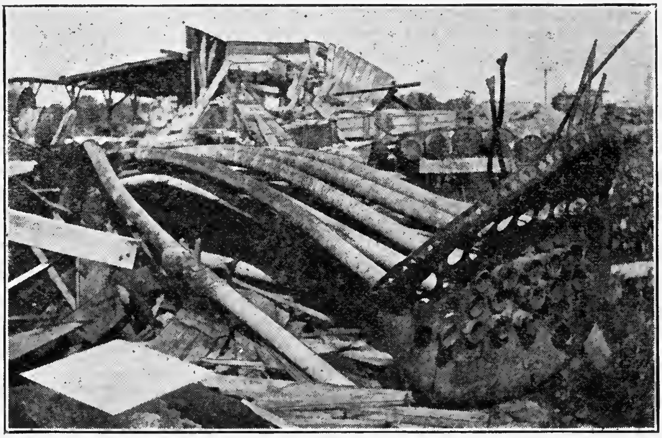

Fig. 7. Close-up view of boiler tubes and head.

seams either sheared at the junction of the plates or the rivet heads pulled off, as none of the rivet holes were destroyed, although some of them were found to be considerably elongated.

After an accident, where there are so many possible causes, it is difficult to define responsibility. In this case the center bracket above the point where the initial leakage and crack developed, most likely supported the entire weight of that side of the boiler, which, as has been outlined, would follow from the settling of the furnace at the front or back bracket, and would clearly justify the modern requirements which provide for four-point suspension only. The factor of safety was not one-half as great as considered necessary by good authorities for boilers of such great age and design, and had a proper factor of safety been maintained, the explosion would not have occurred, as the pressure permitted then would not have been sufficient to operate the plant, and the boiler would have been scrapped.

Had the service of the boiler been limited to ten years, as has been advocated for the lap-seam boiler, its use would have been abandoned years before. The owner no doubt would have experienced some financial loss, but nothing compared to the loss resulting from the explosion. Had the boilermaker who patched the boiler been acquainted with developments of recent years, so far as boiler design and safety are concerned, and the rules which prohibit repairing a boiler in which a lap-seam crack has developed, or had the mill superintendent realized the clear danger warnings and discontinued the boiler from service until the advice of competent persons could be obtained, there would have been no explosion. This accident emphasizes the difficulty of obtaining proper cooperation of boiler owners in enforcing reasonable rules and regulations, as the boiler was being operated without a certificate from the state authorities, who had no knowledge of its existence, and it is doubtful if the owner and those in charge of its operation knew that the boiler differed in any material way from new boilers of modern design.

Fortunately, the installation of new boilers of this description is prohibited in many states and cities, so its manufacture practically has been abandoned, but there are a great number in operation, and the next few years may witness an increasing number of failures, as the defects, undoubtedly existing, develop until rupture takes place. An increase in the factor of safety will result in a reduction of pressure; this may cause the removal of the boiler from its present place of operation, to be disposed of, if there are no restrictions, through dealers in second-hand boilers, only to be placed again in service, to the jeopardy of someone's life and property.

In discussing the Cross Run, Pa., explosion, *The Locomotive,* in the July, 1917, issue, asserts: "The lap-seam boiler has been a fruitful

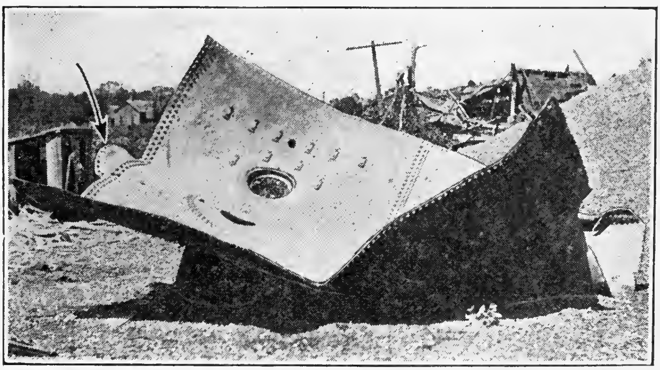

Fig. 8. Shell plates blown free of the ends and tubes.

source of steam-boiler accidents in this country, and of lap-seam boilers perhaps no class has been more subject to disaster than those made in a single course with two sheets, one above and one below." It is evident that the single-sheet boiler "has been weighed in the balance and found wanting." It has sustained injuries during the process of fabrication, is impossible of thorough inspection, has been stressed beyond its safe limit by temperature difference, by continual flexure due to nonconformity to a true circle, by lack of girth-seam support, and by the unequal distribution of the weight of the boiler, contents and connections.

Shall those boilers now in use be continued in service, to change owners and operating conditions at will, until each gives positive and direct evidence of its worthlessness by exploding, with the aggregate loss of another hundred of lives, and of another million-dollar property damage? Or shall the rule against habitual criminals be invoked, and each boiler of that type sentenced permanently to the scrap yard, where it will have no further opportunity to destroy, just as the police character, in whom the bad outweighs the good, is given an indeterminate prison sentence, so he can do no more injury to society? If those financially responsible for the continued operation of single-sheet boilers could be made to realize that immediately preceding each lap-seam boiler accident the owner considered his boiler perfectly safe to operate; or appreciated the fact that under certain circumstances any person might be the victim, as our sidewalk basement boiler rooms, hotel power plants and department store power plants, if they do not contain unquestionably safe equipment, place the lives of all in jeopardy; or realized that defective boilers endanger the lives of the employees to whom the employer owes the moral responsibility of furnishing safe tools—then there is no question that the verdict would be, "The single-sheet boiler must go."

CHANGING OLD LAP SEAM BOILERS TO BUTT SEAM CONSTRUCTION.*

Not long after the steam boiler came into general use in America considerable discussion was aroused with respect to the question of limiting the life of a boiler. Numerous instances of serious accident, which it seemed impossible to account for, had impressed many with the

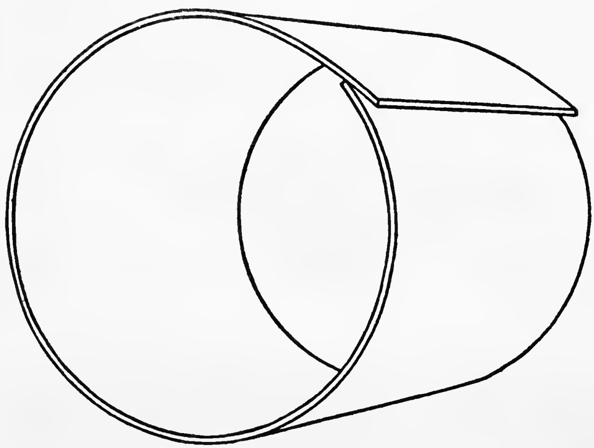

Fig. 1. When plates are rolled to a cylindrical form there is a tendency for plate edges to remain flat as in this case.

idea that a boiler, like any other piece of apparatus, was subject to deterioration from constant use and that therefore it would be best to take a boiler out of service after a certain period. In fact, a number of concerns followed this practice. The majority of boiler users and

*From *The Locomotive,* Hartford Steam Boiler Inspection and Insurance Company, Hartford, Conn. Cuts to illustrate this reprint were loaned by *The Boiler Maker,* 6 East 39th St., New York.

engineers, however, felt then, as they do now, that rigid inspection would safeguard their boiler plants and would furthermore be of greater service in the interest of economy, for it was admitted that many boilers had served for twice the life that, by some, had been allowed for safety.

The plan of relying on inspection for a forewarning was adopted and served well, but there were a number of unaccountable explosions in boilers of relatively short life. At the time, the majority of boilers in use were constructed with a longitudinal lap joint. A series of investigations was conducted to study the stress conditions in this type of joint, and it was found that the construction, both from its fundamental shape and the conditions of manufacture, presented a most dangerous condition.

In *The Locomotive* for April, 1905, there appeared an account of the disastrous boiler explosion at Brockton, Mass., on March 20, 1905, and also an article on the "Lap-joint Crack," to which type of defect the explosion was said to be due. For the sake of clearness we shall present here some of the more important points which were brought out in the last-named article.

When a boiler plate is rolled to a cylindrical form the edges of the plate, in passing through the rolls, are not gripped as effectively as is the middle of the plate, so that the ends are left somewhat flat. The condition produced is illustrated in Fig. 1. This necessitates the plates being forced together at the edges, and this produces an added stress that persists unless relieved by annealing. In addition to this, the plates, if bent after punching, will bend along a line of rivet holes as shown in Fig. 2 in somewhat exaggerated form.

The elementary lap joint is illustrated in Fig. 3. If tension is applied as indicated in Fig. 4, the plates, in an attempt to aline themselves with the load, will bend along a line running under the outer edge of the rivet heads.

The combined effect of all these conditions, together with the constant bending of these joints by changes of pressure when in use, is to impose excessive stresses in the surface of the boiler plate along the line just mentioned. This has produced, in many boilers, a crack which starts always from the inside or covered surface of the inside or the outside plate of the joint as indicated at *A* and *B* in Fig. 4. This crack may eventually work its way through the plate until it shows itself by leakage. But in many cases it may develop for some distance along the joint and yet remain absolutely invisible. Eventually the weakness may develop to the point of complete failure and a disastrous explosion.

Inspection is generally accepted as being safe for the determination of the fitness of a boiler for use. The lap seam crack, however, is invisible to all methods of inspection, except cutting out the rivets and separating the plates. Recognizing the insidious danger presented in the lap joint for longitudinal seams in boilers, the Boiler Code Committee of the American Society of Mechanical Engineers formulated the following regulation (par. 380, A.S.M.E. Boiler Code, edition 1918):

"The age limit of a horizontal return tubular boiler having a longitudinal lap joint and carrying over 50 pounds pressure shall be 20 years, except that no lap joint boiler shall be discontinued from service solely on account of age until 5 years after these rules become effective."

Some boiler owners may be of the opinion that the longitudinal lap seams of boilers of this type can be changed to butt strap construction and the boilers kept in service after the time limit. This change of design and construction is not approved, however, by those thoroughly familiar with steam boilers, for, although butt straps and more rivets may be added, the material along the line of the joint, which was abused and tortured by the forming of the lap joint and fatigued by the years of service which subjected it to the expansion and contraction brought about by the many changes of temperature and pressure, would be further abused on the portion of the original construction left after cutting off one side of the lap joint and forcing the edges of the plate into line to form a butt joint.

Assuming that a double riveted lap joint has been changed to a triple riveted butt construction, the joint, after placing the butt straps and riveting, would appear as shown in Fig. 5 with the rivet holes of the original lap joint at *B* and the new holes at *C*. If a defect existed in the

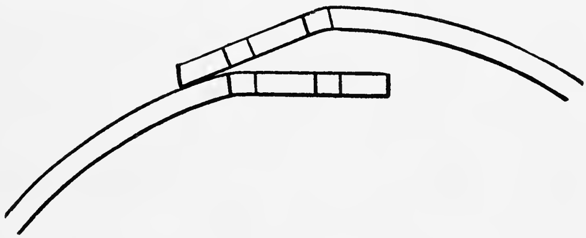

Fig. 2. If bent after punching, plates will bend along a line of rivet holes.

plate as shown at *A* the joint would be very faulty. Assuming the original joint as having the rivet holes spaced 3¼ inches and the additional holes spaced 6½ inches, if the plate material were defective or contained a lap crack as shown, the failure of the joint would require only the shearing of the rivets in long pitch, or 6½ inches, and the failure of the defective plate.

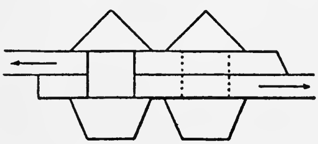

Fig. 3. Elementary lap joint.

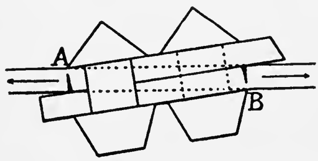

Fig. 4. Effect of tension on joint.

It might be argued that the exposure of the inside of the lap seam, when the change to a butt seam is made, would reveal the presence of a lap-seam crack. A crack of this nature is, however, often present in a boiler of this construction after years of service, although it may not be visible to the naked eye. But even though no crack exists it must be remembered that boiler plate, like any other material, becomes fatigued after long years of service, and for this reason, after it has been under stress for many years, it should not be subjected to a change of shape and torture of the material in an endeavor to keep the boiler in service, especially when there is evidence that the altered structure is defective.

The age limit of twenty years is none too exacting, as will be evidenced by an explosion resulting from a lap seam crack of a boiler at the Tallahoma Lumber Company at Mossville, Miss., on October 21, 1920.

This boiler was less than five years old. The explosion completely wrecked the plant, killed three men and injured four others. There was no negligence on the part of the operators and there was ample proof that the accident did not result from low water or overheating. On the other hand, the lap seam cracks could be clearly seen in the boiler plates after the disaster.

Regulations such as we have quoted are not intended to be arbitrary. Railroad companies determine the safe load capacity for each of their freight cars, and if they discover an overloaded car they refuse to trans-

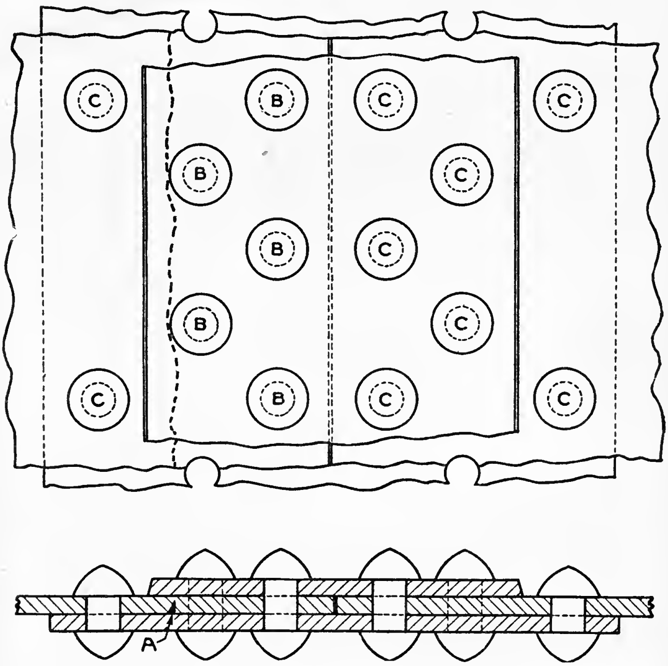

Fig. 5. Double riveted lap joint changed to triple riveted butt strap type.

port it. This is done not only to avoid the possibility of straining and breaking the overloaded car, but also to prevent a possible wreck which might result in loss of life, property damage and delay. In a like manner the Boiler Code Committee requests that steam boilers and pressure vessels be designed and constructed for a safe working pressure and that they be not subjected to overloads. The rule quoted above is sane and economic because it is intended for the protection of life, limb and property. So also should be regarded the action of the boiler inspector condemning any construction regarded as unsafe.

LAP SEAM CRACK CAUSES BOILER FAILURE IN PLANING MILL.*

[Reprinted, by permission, from April, 1921, issue of *The Boiler Maker.*]

Many of the details of boiler making, and in that term we, of course, include boiler repairing, have found no place in written language but may be said to be traditional, being handed down from the journeyman to the apprentice, by word of mouth. Other details may be said to be proprietary, that is, some workman experiments with new processes, until he becomes acquainted with some formerly unknown fact, applicable to the trade, of which he immediately takes advantage, with satisfactory personal results, and with some permanent benefit to the trade in general, when the detail becomes more widely known.

The good workman is proud of the results of his efforts, and when trade-pride ceases to exist, whether he be manufacturer or workman, he may no longer be depended upon, and sooner or later his work will become outclassed. In order to obtain satisfactory results, a complete understanding of the trade is essential. The boiler maker doing repair work is thrown more upon his own resources than is the workman engaged in routine shop work. When on new construction, the foreman and other journeymen are usually near at hand for advice when necessary. It may be said, however, that friendly counsel and conferences of a trade nature are far too uncommon.

Experience Required in Repair Work.

At any rate, when a call for outside repair work is received, one of the most capable and experienced men in that class of work is, or should be, sent to the job, for it is impossible to determine the far reaching effects

Fig. 1. Result of boiler explosion in planing mill, Antlers, Okla.

of a lapse in judgment, when outlining the repairs to be made, and the manner of making them. The owner of a boiler is anxious to obtain the greatest possible term of service, consistent with safety, and is often

*Cuts to illustrate this reprint were loaned by the publishers of *The Boiler Maker,* 6 East 39th St., New York.

willing to spend more for patches, new tubes, or resetting, than the value of the boiler warrants. Of course, if permanent, safe and satisfactory repairs are possible, no one should object to a patch of proper dimensions, properly applied, but the boiler maker should have sufficient judgment to determine ,and sufficient confidence to refuse, if repairs should not be made, for otherwise lives and property are placed in danger.

Lap Seam Crack in Boiler Causes Explosion.

At 7:30 a.m., September 20, 1920, the town of Antlers, Okla., was shocked by the explosion of a boiler located in a planing mill at that place. The plant was totally wrecked, and two men were killed, while two others were seriously injured. The head of one of the men who were killed was completely severed from the body.

The immediate cause of the explosion was a lap seam crack, which extended from the front head to the rear head of the boiler, along the

Fig. 2. View of shell plates, showing patch and extent of crack.

longitudinal seam, and which no doubt had been years in fully developing. The complete history of the boiler was unknown, but it was said to have been purchased second hand, provided with usual safety appliances, and placed in operation at 100 pounds pressure, which was continued until leakage was observed at the longitudinal seam on the right hand side, when facing the front.

The home made brand of calking, provided by those in charge, was not sufficient to stop the leakage, so a boiler maker was sent for, and patching was determined upon. The patch can be seen plainly in Fig. 2, which also shows the extent of the seam failure, and the shell plate detached from the heads and tubes, resting where it landed, about 300 feet from its original position.

Fig. 3 gives a close-up view of the patch, and crack which extended through the threaded holes, used in securing a soft patch, which had been applied by those in charge of the plant.

It is possible that the boiler maker who made the riveted patch repair looked with pride upon his work, for the patch was tight, and while its shape could have been improved upon, its workmanship was above the average. It is further probable he had never heard of a lap seam crack. This is a defect thousands of men are seeking daily, in order to prevent just what took place at Antlers, and if this mechanic had been thoroughly posted upon the developments which have taken place in his trade in recent years, the designs which have proven faulty, and the many failures of lap joints, due to the lap joint cracking, he could have prevented the disaster, by refusing to make repairs.

Many of the states have adopted laws regulating the material, design, construction and operation of steam boilers, but few of them have dealt

Fig. 3. Close-up view of patch and crack.

extensively with rules controlling boiler repairs. However, there is one requirement which has been almost universally adopted, which prohibits the repairing of a sheet in which a lap seam crack has developed.

The A.S.M.E. Boiler Code limits the pressure on lap seam boilers to 50 pounds after 20 years of service, and likewise prohibits repairing the sheet of a boiler in which a lap seam crack has been discovered. The loss of life and damage to property at the Antlers planing mill alone, to say nothing of the great number of similar explosions which have occurred elsewhere, clearly justifies the Code requirements, and every boiler maker called upon to tighten by calking, or repair by patching the longitudinal seam of a lap seam boiler, should refuse to make repairs until it is clearly demonstrated that a lap seam crack does not exist.

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