Boiler Laws Committee

1920-21

REPORT

DELHI
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1921

BOILER LAWS COMMITTEE.

No. 23-B. C.

Dated Delhi, the 10th March 1921.

FROM

F. D. ASCOLI, ESQ., I.C.S.,
President, Boiler Laws Committee.

TO

THE SECRETARY TO THE GOVERNMENT OF INDIA,
DEPARTMENT OF INDUSTRIES, DELHI.

SIR,

I have the honour to forward herewith for the information and orders of the Government of India the report of the Boiler Laws Committee. The Committee was constituted by Resolution No. A.-61, dated Simla, the 11th November 1920, as amended by Resolution No. A.-61, dated Delhi, the 19th November 1920. The Committee commenced its tour on the 25th November 1920 and returned to Delhi on the 20th February 1921; during its tour it visited all the provinces of British India, with the exception of Baluchistan and the North-West Frontier Province. The evidence of witnesses both official and non-official was obtained in writing and by oral examination except in Assam, where the proceedings took the form of a conference with representatives of the Assam Government and of the tea-planting community. In addition to the usual evidence a conference of mechanical engineers was held at Calcutta on the 7th January 1921. In continuation of the report we have added an Appendix containing a draft Act on the lines of which legislation might be undertaken, and draft regulations and rules framed under the draft Act in accordance with the views arrived at in the report.

I have the honour to be,
SIR,
Your most obedient servant,

F. D. ASCOLI,
President,
Boiler Laws Committee.

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REPORT.

I.—The Existing Law.

The object of boiler legislation.

1. The necessity for boiler legislation is due to the fact that the steam boiler is an extremely dangerous instrument, that is liable to explode with disastrous consequences on account of faults in design and construction, the effects of wear, tear and usage and as the result of careless handling and management at the time of working. The object of boiler legislation has been to protect life and property from the dangers of such explosions. In India this object has been achieved mainly by insisting on the periodical inspection of boilers by Government agency, with the result that explosions are now of very rare occurrence. These inspections are of a twofold nature, the distinction between which has not been sufficiently emphasised in the laws at present in force. The first form of inspection relates to the survey of a boiler when first examined for use in India, and in a minor degree when structural alterations or renewals are made to a boiler; this survey is intended to test the design and construction of the boiler, to ensure that the boiler comes within a specified standard of safety, and to fix the initial pressure at which it may be worked with safety. The second form of inspection is concerned with subsequent periodic surveys of a boiler; the object of such survey is to detect any deterioration in a boiler due to wear and tear, damage in transit, foul feed water or defective management, and to determine whether any reduction of pressure is necessitated by such deterioration. The former type of survey consists theoretically in a complete measurement of the boiler and approval of the materials used in construction against certain prescribed theoretical standards, combined with a practical hydraulic test of strength. The second type of survey consists in a complete internal and external visual examination to detect signs of deterioration in the boiler, further practical tests of parts where deterioration is detected against the same theoretical standard, and a similar practical hydraulic test of strength. Theoretically the same standard of test and working pressure should be invariable throughout the world; in practice the standard varies considerably in different parts of India, owing to the existence of different Acts, rules and regulations. These inspections and surveys constitute the backbone of boiler legislation in India for the protection of life and property. In a large area attempts have been made to secure a further degree of safety and to ensure the proper handling and management of boilers by insisting on the possession by the person in charge of a boiler of certain qualifications—qualifications of different degrees, which are determined by examination. The necessary qualifications and standard of examination differ materially in different parts of India. In other parts of India, however, it is maintained that for the safe working of a boiler, it is unnecessary to insist on such qualifications, and that the qualifications

necessary are a modicum of knowledge, years of experience and carefulness—a quality which no examination can test or ensure. Where the higher qualifications are insisted on, the object of the law tends to be misinterpreted as being mainly in the interests of the owner, *i.e.*, for the maintenance of the condition of his boiler, and the main object and sole justification of the law—namely the protection of life and property—tend to be lost sight of. The remaining provisions of the law are subsidiary to the inspection and management of boilers and are largely administrative in character.

Legislation in the British Isles.

2. In the British Isles no law exists for the compulsory inspection of steam boilers on land by an official agency or for regulating the management and control of such boilers by certificated men. Attempts to introduce such legislation from time to time have met with the strongest opposition, and as recently as 1910 a "person-in-charge" bill was introduced and abandoned in the House of Commons. But it is a mistake to think that the position is analogous to the position in India. It is also a mistake to think that boilers in the United Kingdom are exempt from control. Provisions regarding steam boilers in Factories and Workshops are prescribed by section 11 of the Act of 1901, in Metalliferous Mines by Acts of 1872 and 1875 and in Coal Mines by section 56 of the Act of 1911; these Acts prescribe the safety devices to be fixed to every boiler; they require every boiler and its fittings to be maintained in a proper condition and lay down provisions for the periodical inspection of all such boilers by competent persons together with a record of such inspections. It is important to remember that in the United Kingdom it is the custom to insure boilers against the risk of accident or explosion, and that on this account steam boilers are subject to inspection and control by influential Boiler Insurance Companies and Associations. The inspections required by the various Acts are customarily made by Inspectors, the certificates being countersigned by the Chief Engineers, of these Companies and Associations; and it is largely in deference to the value of the work of these bodies that attempts to introduce an official inspecting agency have failed. Under the provisions of section 17 of the Factories and Workshops Act, 1901, powers are given by the legislature to prohibit summarily the use of a steam boiler in a dangerous condition, while the Boiler Explosion Acts of 1882 and 1890 provide for reports of explosions by the owner or user and for formal enquiries into the cause of the explosion. It should be noted that in these latter Acts, in which alone a steam boiler is defined, the definition is in very wide terms and includes steam pipes. It should also be noted that in the British Law the definitions of factories and workshops are so wide, that all boilers, with the exception of certain portable and vehicular boilers, that are liable to inspection in India, are also subject to the control of the law of the United Kingdom.

Possibility of inspecting in India through Insurance Associations.

3. It has been suggested that it might be possible to adopt in India a system similar to that prevalent in the United Kingdom. We have carefully considered the suggestion but have arrived at the conclusion that it is impracticable. The evidence that we

have heard shows unanimously the popularity of official inspection and the confidence resulting from the fact that it is done by a Government agency. The inspection is generally efficient, effective and economical—far cheaper than would be possible in the hands of a private commercial concern, the ultimate aim of which must be the payment of a dividend to its shareholders. It is obvious that in India the same confidence would not be placed in an inspection at the hands of a private commercial company. It is doubtful if such a scheme could be initiated for other reasons. It is a known fact that it is not the ordinary practice in India to insure boilers, and it is stated that the leading Boiler Insurance Companies and Associations are not prepared to extend their operations generally to this country. It is a matter for grave doubt whether it would be possible to organise a similar Insurance Association for India, and it is beyond a question of doubt whether even a small proportion of the owners or users of boilers would avail themselves of the facilities afforded by such an Association; it is certain that the small owner would not. If insurance were made compulsory, we cannot see what advantage would exist over the present system—a certain disadvantage would be an increase in the cost of inspection and a consequent deterrent to industrial progress and the creation of a special staff to prevent the avoidance of insurance. The inspection of a boiler in an outlying area of a province is at present made at a loss, the excess ordinarily being covered by the profit derived from inspection fees in areas where boilers are numerous. If inspection were done by a private association, the profit of every transaction would be the first consideration, and the cost to the owner of a small installation in an outlying area would be abnormal. There is accordingly in India no alternative to inspection by a Government agency.

Origin and development of boiler legislation; Bengal and Bombay.

4. Legislation regarding the inspection of steam boilers other than marine boilers in India was first undertaken in the year 1864. As a result of a very serious explosion in Calcutta in December 1863 which occasioned the loss of 13 lives, a bill was introduced in the Bengal Council to provide for the inspection of steam boilers and of machinery worked by steam in the town and suburbs of Calcutta. The bill met with considerable opposition and in its final form as Act VI of 1864 provided only for the inspection of steam boilers and prime-movers in the town and suburbs of Calcutta; the Act was based on Act V (Bengal Code) of 1862, which provided for the inspection of boilers on steamships. In accordance with rules framed under the Act the inspecting staff and the administration of the Act were in 1875 placed under the control of a mixed Commission of officials and non-officials under the presidency of the Commissioner of Police, Calcutta. In 1879 the Act was repealed and replaced by Act III (Bengal Code) of 1879; the main difference in the new Act was the power conferred to extend its operation to areas outside the town and suburbs of Calcutta. Minor amendments were made to the Act in 1903 and 1915; but the principles remain unaltered. The Bengal Acts have never required the employment of certificated engineers. The origin of legislation on similar lines in Bombay was the occurrence of two fatal accidents in the City of Bombay due to explosions of boilers. The original Act (VI, Bombay Code of 1869) was based on Bengal Act VI of 1864; it applied to steam boilers and

prime-movers in the City of Bombay only and placed the work of inspection under the control of a mixed commission. Two serious explosions that occurred at Broach and Ahmedabad in 1871 proved the necessity for the extension of the Act beyond the limits of the City; it was pointed out that factories were "managed in a great measure by men who have but a slight acquaintance with the nature and management of steam machinery". The original bill provided merely for the extension of the Act outside the limits of Bombay City. In a note of the 11th April, 1873, recorded by His Excellency the Governor, it was pointed out that the main reason for legislation was the inefficiency of the men then employed in charge of steam machinery; it was accordingly decided to insist on the employment of certificated men in charge of steam engines. Despite very bitter opposition, this provision became law in Act V of 1873. In view of the existing controversy over the necessity of employing certificated men, it is interesting to note that their original introduction was due rather to the requirements of steam machinery generally than to boilers in particular. The initial examination rules were based on the Board of Trade Regulations for Marine Boilers and Engines as adapted for use in Bombay. In 1887 a new Act (III of 1887) was passed; strong opposition was again raised to the clauses regarding certificated engineers, on the ground that if any certificate were required, it should be given to the man in immediate charge of the boiler and not to the supervising engineer; the Act contained provisions for granting certificates on the basis of experience in addition to certificates granted after examination. In 1891 the Act was replaced by Act II of 1891 which subsequently gave way to the existing Act V of 1917. This Act differs in three very important matters from the existing Bengal Act; it dispenses with the existence of a mixed commission for the control of inspection work, and excludes the inspection of prime-movers, while on the other hand it retains the provisions requiring the employment of certificated engineers. Administratively the main difference lies in the fact that, whereas the Bombay Act is in force throughout the whole Presidency, in Bengal the Act applies only to certain notified areas. The Bengal and Bombay Acts constitute the basis of all boiler legislation in India.

Boiler legislation in other provinces.

5. In three provinces, *viz.*, Assam, the North-West Frontier Province and Baluchistan no law for the inspection of steam boilers is at present in existence. In Bihar and Orissa the Bengal Act is in force and the administration of the Act is in the hands of the Bengal Boiler Commission; in Delhi the Punjab Act is in force. Each of the other provinces has framed legislation on its own particular lines, the principles being based on the Acts of Bengal and Bombay. The history of this legislation may be briefly recorded.

(*a*) *The Punjab.*—Proposals for legislation were originally made in 1891 as the result of a boiler explosion at Chunian. No Act was passed, however, until 1902 (Act II of 1902). The Act was based on the North-West (United) Provinces Act and paid scant regard to the existence of other legislation on the subject. Under the Act certificated engineers are required,

no boiler commission has been constituted and the Act applies only to notified areas.

(*b*) *The Central Provinces.*—In 1904 proposals were made for extending the Bombay Act of 1891 to the Central Provinces on the ground that the Act was already in force in Berar (amalgamated with the Central Provinces in 1903), that the number of boilers was rapidly increasing and that a practice had arisen of importing defective second-hand boilers in a dangerous condition from Bombay. A new Act was framed on the basis of the Bombay Act—except for numerous improvements in drafting and the relegation of much detail from the Act to rules, no material alterations were made. The Act (II of 1907) is in force over the whole of the Central Provinces and Berar.

(*c*) *Madras.*—In 1892 it was felt that owing to the increasing industrial importance of the Presidency it was necessary to legislate for the inspection of boilers and prime-movers on the lines adopted over the greater part of India. The new Act was based on the Burma Act with modifications based on the Bengal and Bombay Acts. Under the Act, which became law as Act III of 1893, no Boiler Commission was created; power was given—a power which has never been exercised—to insist on the employment of certificated engineers—while prime-movers could only be subjected to inspection by special notification—no such notification has been issued. Originally the Act applied only to the City of Madras, but in 1899 it was extended by notification to the whole of the Presidency; it is interesting to note that its provisions are in force in neighbouring native states such as Travancore. In 1904 and 1909 minor amendments were made to the Act. In 1904 a notification was issued requiring all engine-drivers in Municipal Waterworks to take out certificates under the Act; in 1905 this was made applicable to all engine-drivers in Government service.

(*d*) *Burma.*—In 1881 proposals were advanced for the framing of a Boiler and Prime-movers Inspection Act in order to bring the ports of Burma into line with those of Bengal and Bombay. The Bengal Act of 1879 was adopted with one important addition, *viz.*, the necessity of retaining certificated persons in charge of boilers. These proposals became law in Act XVIII of 1882, which was made applicable to the towns of Rangoon, Akyab, Bassein and Moulmein. In 1898 the Act was extended to 5 other towns, and in 1906 a Boiler Commission was established to control the work of the Boiler Inspectors, who had recently been made whole-time officials. In 1908 the Boiler Commission proposed that a new Act should be passed—the main defect in the Act of 1882 being that it contained no legal provisions for the constitution of the Commission. A new Act was accordingly framed, and

became law as Act II of 1910. It is interesting to note that in framing the Act the law in force in other provinces was not considered, until the Government of India called attention to the provisions of the new Central Provinces Act (II of 1907). The rules framed under the Act were, however, based on those in force in Bengal and Bombay. This Act has been extended subsequently to the whole of Burma excepting certain remote areas, where the difficulty of arranging for regular inspection and of obtaining certificated men in charge of boilers is great.

(*e*) *United Provinces.*—The first Act in the United Provinces was passed in the year 1899 (Act I of 1899) as a result of a considerable number of boiler accidents and the increasing industrial importance of the province. Proposals for amending the Act were first made in 1911, and in 1913 it was decided to frame an entirely new Act with the object of bringing it into line with the Indian Factories Act and removing certain important defects regarding the use of boilers in an unsafe condition, accidents and control over repairs and alterations to boilers; the bill provided for the appointment of a Chief Inspector. The bill finally became law as Act III of 1915. The Act is one of special value, as it alone, of all Boiler Inspection Acts in India, was framed after consideration of other existing Acts. The Act applies to the whole of the province; it excludes prime-movers except by special notification, and requires the appointment of certificated engineers. It provides in detail for the employment of a Chief Inspector, and prescribes an improved system of appeal.

Differences in the Acts.

6. It is an extraordinary fact that the seven different Acts show little indication that the various legislatures have attempted to take advantage to any considerable extent of the legislative labours of other provinces. Even where such has been the case as in the Central Provinces, no attempt has been made to consider the necessity of amendment, when the Act from which the Central Provinces measure originated (Bombay Act II of 1891) was repealed as obsolete, and replaced by a new Act in 1917. The existing Punjab Act of 1902 is based on an obsolete and repealed Act of 1899; Bengal has been content to retain an Act of 1879, subject to a few minor amendments, despite the fact that conditions have altered to a very large extent in the past 40 years, and despite the subsequent legislative labour of six other provinces. The Acts differ not only in form but in principle. The principle of insisting on the necessity of employing certificated engineers in charge of boilers was, as has been shown, initially adopted by Bombay, and has subsequently been accepted by all other provinces except Bengal and Madras; in Bengal the necessity of a certificate has never been admitted; in Madras the Act of 1893 allows for the issue of such certificates, but the power has never been exercised, except in the case of persons in charge of Government machinery. In Bombay, Madras, the United Provinces

and the Central Provinces and Berar, the Acts are in force over the whole of each province; in the other provinces they apply only to notified areas. In Bengal and Burma alone the administration of the Acts is in the hands of a commission composed of officials and non-officials, and the inspecting staff does not constitute a Government service. In Bombay alone prime-movers are absolutely excluded from the provisions of the Act; in Madras, the United Provinces and the Central Provinces the section relating to prime-movers has never been enforced, while in the rest of India the provisions of the law are, for all practical purposes, administratively ignored. Every Act contains inoperative and impossible provisions, which have survived from the days when Inspectors were not whole-time workers and provisions were required in the law for ensuring the prompt disposal of the work. Every province has adopted a different definition for a boiler, the differences being in some cases of vital importance. Exemption of boilers of different classes differs widely in principle. It is a relief to point to one single underlying principle, *viz.*, that boilers generally should be liable to inspection at certain periods and should not be permitted to work except under a certificate, stating the maximum pressure to be used. It is obvious that such differences as exist cannot be justified by the particular requirements of local conditions; on the other hand they point to an unjustifiable waste of legislative endeavour.

Differences in existing rules.

7. The provisions of each Act are supplemented by series of rules for administrative purposes; differences exist in these rules of far more serious importance than those in the Acts themselves. The rules may be classified generally under the following heads:—

(*a*) Administrative Rules.

(*b*) Technical Rules.

(*c*) Inspection Rules.

(*d*) Rules for the examination of certificated engineers.

It is not necessary at this stage to enter into the differences in detail; the rules under headings (*b*) and (*c*) are of a purely technical nature and theoretically could not justifiably admit of variations to suit local conditions. In every case the rules are presumed to be based on the Board of Trade Regulations for Marine Boilers—the differences are due partly to a failure to appreciate the method of adaptation adopted in other provinces, partly to the adoption of Board of Trade Regulations of different dates. Constants and formulæ vary accordingly to a surprising extent, with the result that the pressure permissible for the same boiler may vary to an extraordinary degree in different provinces. In the Punjab no technical rules for the determination of pressure have been prescribed and the inspecting staff works, with no legal sanction, under the ægis of the Bombay rules. Four out of seven provinces lay down a formula for calculating the nominal horse power of a boiler—in every case the formulæ differ. Two standards exist for fixing the minimum size of safety valves—one being double the other. In only two provinces are the standards for hydraulic tests the same. To such an extent do the standards and systems of examination for certificated engineers and drivers differ, that it is rare for one province to accept a certificate granted in another. It is

obvious that such differences in rules, which are in their nature purely technical, must result in grave interference with industrial development, so far as the use of steam machinery is concerned.

II.—Discussion of the Main Problems.

Arrangement of the Report.

8. The resolution by which the present Committee was constituted narrates succinctly the difficulties occasioned in India by the existence of seven different Acts and seven different sets of rules and regulations. In the terms of reference we have been instructed to report on two general problems and on one particular contentious matter. The general problems under consideration are the possibility of introducing a uniform standard throughout India for steam boilers, and the possibility of unifying the law and regulations relating thereto; the particular problem relates to the desirability of insisting on the possession, by persons in charge of boilers, of certificates of competence or experience, issued by Government. We propose in our report to deal initially with the two general problems as briefly as possible—the problems are not in fact contentious—to state the result of our enquiries regarding the particular problem, after disposing of two special aspects of boiler legislation, which affect the question of insisting on certificates for persons in charge of boilers, and finally to submit our proposals for the unification of the Acts at present in force and of the rules and regulations framed thereunder, supported by a draft Act on the lines of which an All-India Act might be framed, a uniform set of technical regulations and a model set of administrative rules, which are based on the results of our enquiries.

Causes and effects of diversity in standards.

9. The introduction of a uniform standard for steam boilers implies the framing of regulations for the material, design and construction of steam boilers, on the basis of which the maximum pressure at which a boiler can be worked is calculated. With the exception of the Punjab, all Provincial Governments, which have passed Acts on the subject, have framed regulations laying down such a standard. In all cases the regulations have been framed on the British Board of Trade Regulations for the design and construction of Marine Boilers—the only authoritative official publication on the subject. It might be thought that this would result in complete uniformity. This has not been the case for two main reasons :—

(*i*) the regulations in different provinces in India have been based principally on Board of Trade Regulations of different dates; these differ very considerably and they are all now obsolete;

(*ii*) the Board of Trade Regulations refer to marine boilers only, there being no official publication relating to land boilers. It is possible to standardise the general requirements of marine boilers to a far greater extent than those of land boilers, the types of which, *e.g.*, Cornish, Lancashire, externally fired, tubular, vertical, locomotive, etc., are numerous; in land boilers materials (*e.g.*, iron) may be used, which would

ordinarily be prohibited in marine boilers. Regulations for land boilers must take into account small types of boilers, *e.g.*, those of fire engines, which are unknown at sea. It will be realised that without the control of any co-ordinating authority regulations for marine boilers afford scope for extraordinary differences, some of which may be theoretically justified, others that cannot even seek protection under this plea, during the process of adaptation to the requirements of land boilers. In some instances, where adaptation is essential, the marine regulations have been accepted unaltered; a conspicuous example of this labour-saving method is the insistence in several provinces on a 2" diameter for safety valves, a size which would be attended by ludicrous results in the case of small boilers of the fire-engine type. There is no justification for differences in the regulations in different provinces—the regulations are entirely technical in nature and cannot be affected by local conditions. It is obvious, however, that such differences must exist, unless the regulations are framed by a single authority. The actual result has been that a boiler, that has been passed for a certain pressure in one province under the regulations in force, may fail altogether to pass the test or may only pass the test for a lower maximum pressure in another province. Such instances have been specifically brought to our notice. We are not prepared to ascribe the reason entirely to essential differences in the regulations; in the inspection of boilers the personal element is a weighty factor, and the differences in the regulations in different provinces have resulted in what we would term "provincial jealousy," one province attempting to show that its inspection work and its regulations are superior to those of another province. However, pernicious this attitude may be, we are convinced that it is a fact—one that is not likely to be remedied, unless all provinces are subject to the same regulations and unless the work done in one province must be legally accepted as correct in other provinces. Practical examples of the evil effects of such diversities have been placed before us. The disadvantages of diverse regulations are not, however, confined to inspection work; manufacturers, importers and owners of boilers have complained bitterly and justifiably of the arbitrary differences existing in different provinces and the consequent obvious difficulties which they must encounter. The manufacturer in England and in other parts of the world can justifiably plead that it is impossible for him to construct up to any definite standard, where the regulations of any province may be altered from time to time without real technical justification, possibly to meet the whim of a Chief Inspector. A specific example was brought to our notice of the proposed rejection by the Madras Government on the basis of a defective rule of a standard boiler manufactured by a leading firm of boiler manufacturers, Messrs. Babcock

and Wilcox, for a defect which in the rest of the world is considered sound boiler practice. With a single set of regulations in force for the whole of India, manufacturers cannot complain of ignorance of the standard required.

Basis for prescribing a uniform standard.

10. The difficulties resulting from the existing system were brought to the notice of the Government of India by the Government of Madras in the year 1912. It is unnecessary now to enter into the details of the correspondence; for various reasons a decision was postponed pending the appointment of the present Committee to report on the general question of boiler legislation in India. The evidence on the necessity of framing a uniform standard for the whole of India has been unanimous, and in order that uniformity may be arrived at and maintained, the principle has been accepted, that the standard should be laid down by the Government of India, and that no modifications of that standard should be made except by the Government of India. In accordance with this decision and in virtue of the fact that under the scheme of constitutional reform boiler legislation is a function of the Government of India, we have framed regulations laying down a uniform standard for the material, design and construction of boilers based on the latest regulations issued by the Board of Trade. In October 1920, the attention of the Government of India was called to these regulations by the Director-General of Stores, India Office, (*a*) "in the event of any revision and co-ordination of the Indian Boiler Regulations being contemplated"; it was pointed out that there were the strongest reasons, why the boiler requirements of India from the technical side should be alike; the majority of boilers in use in India were made in England, and manufacturers were not often aware that existing requirements differed. The latest Board of Trade Regulations, *viz.*, "Standard Conditions for the design and construction of Marine Boilers, 1920" are based on the report of the British Marine Engineering Design and Construction Committee, convened in the year 1918, as modified by a conference held with the Board of Trade in 1920. This Committee consisted of representatives of the principal marine authorities, *viz.*, the Institution of Naval Architects, the Institution of Engineers and Shipbuilders in Scotland, the North-East Coast Institution of Engineers and Shipbuilders, the Institute of Marine Engineers, the Liverpool Engineering Society, Lloyd's Register of British and Foreign Shipping, the British Corporation for Survey and Registry of Shipping and the Bureau Veritas International Register of Shipping. The proceedings of this influential committee are authoritative, and the revised publication of the Board of Trade has been accepted by the three principal Registers of Shipping. We have accordingly had no hesitation in basing our regulations for standard conditions for the design and construction of steam boilers in India on the latest Board of Trade Regulations. The methods employed in adapting these regulations to the design and construction of land boilers are described in a later stage of this report.

(*a*) Director-General of Stores, India Office, to the Secretary to the Government of India, Department of Commerce and Industry, No. S.-17636, dated the 28th October 1920.

Unification of the Acts and Rules.

11. It follows, if the necessity for uniform conditions for the design and construction of boilers be admitted, that such regulations can only be framed under a single uniform Act—framed by the Government of India and applicable to all provinces alike. The power to frame such an Act now rests with the Government of India by statute. In paragraph 6 of this report we have indicated briefly the differences existing in the Acts now in force; it is unnecessary to recapitulate them in detail. There are few differences that are fundamental, none that are incapable of assimilation; the sketchy Bengal Act of 1879 implies much that is over-elaborated in the latest legislation—the wordy Bombay Act of 1917. There is no Act that does not contain a considerable amount of unworkable and obsolete matter—a survival of days when boiler inspection was in its infancy. We have accordingly prepared a draft Act on which subsequent legislation may be based, assimilating differences in and eliminating unnecessary matter from existing legislation. The main principles of this Act are the appointment of inspectors as Government servants under the control of a Chief Inspector, the enactment of a system of registration of boilers that will be valid over the whole of India—a necessary measure for the maintenance of a uniform standard—of the manner and methods of annual inspection, of a system of enquiry into accidents and of hearing of appeals, and of a series of penalties for infringement of the provisions of the Act. The detailed provisions of this draft Act are dealt with in detail in a subsequent part of this report. In order to avoid unwieldiness of the Act and difficulties in its administration, we have relegated a considerable mass of administrative and technical details to regulations and rules framed under the Act. We have drawn a sharp distinction between regulations and rules. The former deal solely with technical matters, in which uniformity is essential and provisions for local conditions unnecessary, and with the registration of boilers, by which, it is hoped, uniformity in working will be attained. The draft regulations consist of two parts:—

(*i*) Standard Conditions for the material, design and construction of boilers.

(*ii*) Regulations for the registration and inspection of boilers.

In accordance with the evidence that we have heard, we propose that these regulations should be framed and issued by the Government of India, which alone will have authority to alter them. We further propose that Local Governments should have power to issue rules connected with the administration of the Act, and we have, for their guidance, framed model rules, based on the draft Act, in 7 parts:—

(*i*) Preliminary,

(*ii*) Duties of the Chief Inspector,

(*iii*) Duties of Inspectors,

(*iv*) Administrative instructions for the registration of boilers,

(*v*) Administrative instructions for the inspection of boilers,

(*vi*) Rules regarding accidents, and

(*vii*) Rules for appeals.

The rules and regulations are described in greater detail towards the end of this report.

Problems connected with certificated persons in charge.

12. The particular problem submitted to us for consideration relates to the advisability of retaining the law requiring persons in charge of boilers to possess certificates. It is essential, however, to consider first two problems which are of considerable importance in dealing with the necessity of retaining certificated engineers or boiler attendants. These problems are :—

(*a*) Should the Act apply to provinces as a whole, or only to notified areas?

(*b*) Should the Act be applicable to prime-movers?

The application of the first problem may not be apparent, unless the obvious invidiousness and injustice of the position is realised, where an owner on one side of a street may be compelled to retain a certificated attendant at considerable expense owing to the fact that his boiler is situated in a notified area, while his brother owner on the unnotified side of the street is under no such compulsion. The application of the second problem is more apparent and raises the question, whether it is the prime-mover or the boiler, which is really responsible for the existence of the system of certificated men.

Extent of application of Act within provinces.

13. Of the Acts at present in force, those of Bombay, the United Provinces and the Central Provinces alone apply of their own force to the whole of the Province; in Madras the Act has been extended by notification to the whole of the Presidency, while the Bengal, Burma and Punjab Acts have been extended to certain notified areas only. The position is anomalous. Commencing with the axiom that boiler inspection is intended for the protection of life and property and that, if it fails in that, there is no justification for making it compulsory, we must admit that a boiler is an equally dangerous implement and equally liable to explode, wherever it may be situated. We would even advance beyond this admission, and state categorically that the more remote the position of the boiler, the more distant it is from an industrial area, the less likely is it to receive the expert attention required in working, upkeep and cleaning and in the provision of clean feed-water. We find that in provinces where the Act has only been extended to notified areas, such areas are industrial centres. We are accordingly left with the conclusion that the most dangerous boilers in such provinces are exempt from inspection. Such exemption could only be justified on the ground that inspection is impracticable or only possible at an abnormal expenditure. It is possible that such conditions might apply to some of the more remote parts of Burma—despite the fact that Bombay is able to arrange for inspections so far distant as Aden; we do not think that they are applicable to any other part of India. In Bombay a large number of the boilers under inspection are situated in scattered cotton-ginning factories; in the Central Provinces and Berar boilers are scattered widely over the whole of the province with indifferent means of communication. In the south of Madras boilers, situated in the widely scattered tea

gardens and coffee and rubber plantations, are regularly inspected. We see no reason why other parts of India should be exempt. It does not appear that the omission of any area, except in Burma, has been purposive. The original Acts, it is true, only applied to the principal cities; but an Act in origin differs widely from an Act, when once its meaning and importance are understood. Initially it appears that there was considerable trepidation in extending the operation of the various Boiler Acts owing to an apprehension, perhaps a mis-apprehension, that its operation might prove detrimental to industrial progress in newly-developing areas; this is clearly illustrated in the history of the application and extension of the present Punjab Act. There is little doubt that this apprehension was unfounded except in so far as the retention of certificated persons in charge of boilers was compulsory. In Bengal, including Bihar and Orissa, this aspect of the problem has never been prominent, and the question of the general extension of the Act, which the Government of Bengal now accepts as necessary, has never been fully considered. In Burma local conditions may be such as to render the further extension of the Act impracticable. The evidence that we have heard proves the popularity, importance and necessity of boiler inspection and supports our conclusion that the new Act should be in force over the whole of India. We consider this conclusion to be of such importance both in theory and in practice, that we do not propose to facilitate the exclusion of, nor to give Local Governments power to exempt any local area. In section 4 of the draft Act, however, we propose that powers to exclude local areas should be exercised by the Government of India—in order to deal with any exceptional cases that may arise. We would call attention to the fact that in these conditions the first objection to the compulsory employment of certificated persons-in-charge of boilers vanishes.

Exclusion of special areas:-
(i) Baluchistan,
(ii) The tea area of North-east India.
(iii) The indigo area of Bihar.

14. Before considering the application of the Act to prime-movers it will be convenient to discuss suggestions made for the exclusion of certain specific areas:

(*i*) The case of Baluchistan can be briefly dealt with. It is reported that there are only two boilers in existence in the province, but this appears to exclude boilers the property of Government. It is probably inadvisable that Baluchistan should be excluded absolutely from the Act, and we are of opinion that it would not be correct in principle to exclude it under section 4 of the draft Act. It is however obviously impracticable to organise a special staff for the province, and we would suggest that in the very special circumstances of the province some competent official, *e.g.*, a locomotive superintendent, should be vested specially with powers as an inspector, subordinate to the Chief Inspector of Boilers, Bombay.

(*ii*) The case of the tea area of North-East India has been very strongly argued before us by the Chairman of the Indian

Tea Association and at a conference held at Shillong, at which the Government of Assam and representatives of the planting community were present. Tea gardens are practically confined to the Darjeeling and Jalpaiguri districts of Bengal, areas not notified under the existing Act, and to the province of Assam, where no Act is at present in force. Four arguments were advanced against the application of the new Act to these areas :—

(*a*) that accidents are of very rare occurrence ;

(*b*) that inspection by Government will be impracticable owing to difficulties of communication ;

(*c*) that boilers are in charge of efficient engineers, and

(*d*) that special arrangements for inspection exist.

The first argument we are not prepared to accept, and a detailed examination of the boilers would be necessary before it would be possible to arrive at any definite conclusion on this contention. The second argument is not correct. In the planting area of Madras, where distances are far greater, inspection is welcome and successful ; in the greater part of Burma and in the cotton-ginning area of the Central Provinces and Berar means of communication are incomparably worse. The real force of the argument lies in the fact that to prevent dislocation of the industry, inspections must be made between the months of December and March ; as is shown below this will present no difficulty. The third argument is one that could be advanced with far greater claim to acceptance by the jute and engineering industries with which Government inspection is popular ; the qualifications of the engineers employed on the average tea garden fail utterly to support any claim to special treatment. The last argument, *viz.*, that special arrangements exist for inspection, is one that is shared by many industries and is true only to a small extent as regards the tea industry. In certain groups of European gardens inspecting engineers are employed ; in others they are not ; while in Indian-owned gardens they are unknown. Inspection is not complete, nor are we satisfied that it is efficient ; it seems certain that no definite rules are in force for regulating the pressure allowable. It is clear that no special case can be established for the exclusion of the tea industry. There are further reasons for insisting on the extension of the Act to Assam. A considerable number of boilers are employed in other industries—saw-mills, rice-mills, and oil-mills—over these inspection is essential. It was further stated to us by the Inspector of Government Boilers, that owing to the absence of an Act in Assam, it has now become the practice to import into that province boilers, which have been condemned for use by the rules in force in other provinces—the cause that originated a Boiler Act in the Central Provinces. The advantages that would result from the new Act were admitted in full by the representative of Indian-owned gardens, and in part, especially as regards the facilities for the purchase and sale of boilers, by all present at the Shillong Conference. We are unable to recommend that the tea industry should be subject to any special treatment. It is clear, however, that Assam will not be able to provide by itself the

organisation which we propose under the new Act. It will be necessary to complete practically the whole of the inspection within four months; for eight months accordingly the inspecting staff would be idle, unless employed on other work for which it would probably be ill fitted. In any circumstances Assam would be unable to afford the expense of a Chief Inspector. It would accordingly be necessary for Assam to work in conjunction with the supervising and inspecting staff of Bengal—arrangements being made to complete the work in Assam between the months of December and March—such an arrangement would present no difficulty, and we are satisfied that no abnormal cost would be involved. The difficulties of employing certificated engineers in such areas are discussed in paragraph 22.

(*iii*) *The indigo area of Bihar.*—The arguments put forward against the inspection of indigo-factory boilers in Bihar were similar to those advanced in Assam. These boilers are inspected by an engineering firm—Messrs. Arthur Butler and Company—but it is admitted that the test applied is merely one of the conditions of the boiler—there is no test against any definite standard. It is moreover obvious, that it would be impossible to ensure that inspections made by a private firm should follow the lines, or be based on the standard laid down in Government rules; it is further obvious that an exemption under these conditions from the provisions of the Act would result in wider and more obvious claims to exemption. We are satisfied that inspection by Government agency in this area would not be attended by any difficulties.

Inspection of prime-movers.

15. The law regarding the inspection of prime-movers varies considerably in different provinces. The Bombay Act of 1917 excluded prime-movers absolutely from the operation of the Act; in the Acts in force in Madras, the United Provinces and the Central Provinces and Berar prime-movers may be included by notification; in Bengal, Burma and the Punjab alone do the provisions of the Acts extend of their own force to prime-movers. In the former three provinces no notifications have been issued; in the latter group the law, so far as it applies to prime-movers, is a dead letter, except in Burma, where a formal but incomplete examination is made. In considering the necessity of inspecting prime-movers, it is important to realise the circumstances under which prime-movers first intruded in the Acts. It has been shown in paragraph 4 that the original Act, Bengal Act VI of 1864, was based on Bengal Act V of 1862, an Act which provided for the inspection of boilers and machinery on steamships. In a steamship the boilers and the engines are more intimately connected, and an accident or break-down at sea is obviously fraught with greater danger than in the case of steam machinery on land. This distinction was not clearly recognised, and accordingly the inspection of prime-movers became an integral part of the law. The mistake was not recognised until the year 1886, when Bombay Act III of 1887 was under discussion in Council. The reasons then advanced were admirably summarised

in a speech in the Bombay Legislative Council made by the Honourable Mr. Javerilal Umiashankar Yajnik on the 4th March, 1891, in the debate on Bombay Act II of 1891. "When the Act now in force (Act III of 1887) was considered by the legislature in 1886, this point about the application of the Act to prime-movers was carefully weighed. On the one hand it was held that there is much ignorance in this country on the subject of machinery and how to work it. On the other hand, it was maintained that such accidents are rare, that they do not often result in loss of life, that examinations of engines are not generally effective in preventing them, and that there are serious objections to an examination, which requires large engines to be pulled to pieces and put together again, perhaps in a very hurried manner, in order to avert loss from stoppage of a factory". We have little to add to these remarks; the thickness of metal in a cylinder is such as to render an explosion highly improbable, while the absence of heated water under pressure considerably lessens the dangers resultant from such an explosion. If inspection is to be effective, it must necessitate the stoppage of work in large mills and factories for several days—while spare boilers are essential in large installations, it is not reasonable to expect that spare prime-movers should be kept. It is clear that the danger from loose nuts or bolts can only be accentuated by periodic dismounting of the machinery, and that for the obviation of such accidents an annual examination would be of little value. We have been unable to trace any considerable number of accidents which could have been prevented by insistence on inspection. If inspection of prime-movers were to be enforced, the increase required in the strength of the inspection staff and consequent expenditure would be out of all proportion to any possible advantages that might accrue. In these conclusions we are supported almost unanimously by the evidence that we have heard, and we have accordingly no hesitation in recommending that the present practice of neglecting the inspection of prime-movers be confirmed by the exclusion of prime-movers from the new Act. We are satisfied that the powers at present possessed by Factory Inspectors for fencing off and preventing the use of dangerous machinery are sufficient for the purposes of the law, *viz.*, the protection of life and property.

Steam-pipes.

16. The law which required the periodic inspection of prime-movers included not only the inspection of the boiler and the prime-mover, but also that of the steam-pipe connecting them; even in areas where prime-movers are not now included in the Act (*e.g.*, Bombay), rules still exist—without any legal justification it is true—for the inspection of steam-pipes. If the proposals made in the preceding paragraph are accepted, it is still necessary to decide, whether any control over the construction and inspection of steam-pipes should be retained under the Act. It must be remembered that the main steam-pipe, namely, the range from the stop-valve of the boiler or boilers to the stop-valve of the prime-mover or its equivalent, carries steam in a comparatively thin casing at a pressure equal to that contained in the boiler. From figures that have been placed before us, it appears that the only fatal explosions, that

have occurred in recent years, have been explosions of such pipes, and it is obvious that their dangers are incomparably greater than those from the cylinders of prime-movers. We have accordingly taken a considerable amount of evidence on this subject, and the weight of evidence, confirmed by a conference with mechanical engineers held in Calcutta (*vide* Appendix IV), has been in favour of including the main steam-pipe within the scope of the Act. Obviously it would be impracticable to apply the Act to the vast system of piping in a large modern mill or factory and we propose that the provisions of the new Act should apply only to the main steam-pipe as described above. It is accordingly necessary to lay down rules for the material, installation and inspection of steam-pipes. In the technical regulations we have suggested that steam-pipes should be constructed of wrought iron, mild or cast steel only ; the exclusion of cast iron—a decision supported by practically all the technical evidence that we have heard—is due to the fact that though sufficiently strong in itself, the material is unable to stand the shocks and stresses resulting from water-hammer and vibration ; the strength of the pipes is often materially weakened owing to the shifting of the core at the time of casting, with the consequence that the thickness of metal varies considerably at different parts of the periphery of the pipe. It is not proposed that this new regulation should affect existing installations, unless they are condemned on inspection. In order to avoid defects where new pipes are laid down, and to ensure efficient drainage for the prevention of water hammer, we have framed a regulation requiring new installations to be approved by the Chief Inspector. It is obvious that the inspection of the steam-pipe need not be so complete as that of a boiler—in fact the diameter of the pipe is an effectual preventive to internal inspection ; the comparative absence of water to any extent, however, in the piping renders the danger of internal corrosion remote. We have entered in the draft Act provisions for the inspection of steam-pipes, and have framed regulations, based on the technical evidence recorded, for the testing of steam-pipes by hydraulic pressure at the time of installation and at periods of five years ; the test will be made *in situ* after blank-flanging the ends of the pipes and the removal of such lagging as the Inspector may require ; such a procedure will result in the least possible interference with the owner, compatible with the safety of employees. Inspectors will be given powers, subject to the approval of the Chief Inspector, to condemn the piping and to order replacement, and will be authorised to refuse to renew the boiler certificate, until such orders have been carried out. We do not, however, propose to require a special certificate for the steam-pipe as in the case of a boiler ; it will suffice if the results of inspections are systematically recorded in the boiler certificate.

The origin of the law requiring persons in charge of boilers to possess certificates.

17. It has been shown that the extension of the Act to the whole of every province removes one objection to the compulsory retention of certificated persons in charge of boilers ; it will now be shown on the other hand that the exclusion of prime-movers from the Act removes the whole foundation on which their compulsory retention is based. A perusal of paragraph 4 will recall the fact that

this provision of law was first introduced in Bombay Act V of 1873, that it was introduced owing to the bad management of steam machinery generally, and that its introduction met with very strong opposition. This provision of law was retained when Bombay Act III of 1887 was passed, and the opposition centred on the problem of the person who should be compelled to have the certificate—the supervising engineer or the actual boiler attendant. The provisions of the law and the regulations for examinations were based on the Board of Trade Regulations for Marine Boilers and Engines. The existing practice in the five provinces, where certificates are required by law, is based entirely on the precedent of marine requirements. This basis rests, however, on a false analogy. It is obvious that the conditions under which machinery is used at sea and on land are essentially different. While collapsed furnaces in a land boiler may necessitate the closing down of a factory and occasion considerable pecuniary loss to the owner, a similar accident at sea would place a large number of persons in a helpless position of danger. Terrible as may be the effects of an explosion of a boiler on land, they cannot be compared with the catastrophe that such an explosion would cause at sea. The differences in steam machinery are equally marked. In a mill or factory it is possible in case of an accident to close down the machinery without inconvenience to the public, and to arrange for necessary repairs; in mid-ocean the stoppage of machinery and the impossibility of effecting repairs except through the agency of the ship's engineers may bring hundreds of lives into a position of grave peril. The dangers at sea and on land are obviously on different planes, and the necessity of employing at sea persons of proved knowledge and capacity, beyond what is required merely for running boilers and steam engines, is obvious. When the system was adopted for land boilers and machinery in India, this distinction was not recognised. Fifty years ago, it is true, the fact that knowledge of the working of steam machinery in India was very limited might have justified the enforcement of special conditions, had the distinction been recognised; this plea cannot however be advanced at the present time. It must be recognised that the justification of and necessity for employing certificated engineers at sea are not so much the dangers resulting directly from an accident to a boiler or the engines, as the impossibility of closing down the engines and executing repairs except at great peril at sea. In this respect the care of the engine, a more complicated mechanism than a boiler, is of vital importance. It has already been shown that, except in Burma, the inspection of engines has been relegated to a very shadowy position under existing Acts—an implicit recognition of the falsity of the analogy between conditions at sea and on land.

Result of excluding prime-movers from the Act.

18. It is now clear that the necessity of retaining certificated persons in charge of boilers on land must depend on the intrinsic merits of the case. In paragraph 15 we have stated in detail our reasons for excluding prime-movers from the operation of the new Act. It follows that it is impossible to frame provisions in the Act for the examination of and the grant of certificates to persons for anything except a knowledge of boilers—which alone are included in the Act. The examination

could accordingly refer only to the competence of a person to take charge of a boiler—it cannot, unless the Act is to be extended as an Act for the promotion of knowledge of mechanical engineering, cover a knowledge of prime-movers or steam machinery. In all provinces where certificates are required by law, the examination requires a considerable knowledge of steam machinery, and only in the case of the lowest class of engine-driver—a man permitted to hold charge of the very smallest plant, is the examination confined to a knowledge of the boiler only. If the examination were to be confined to such knowledge and the holding of a certificate were necessary for persons in charge of any boiler, it follows that the lowest class of driver must necessarily be promoted to the charge of the largest boilers. Such a position obviously implies the existence of a fallacy and appears to reduce the existing position *ad absurdum*. Of the witnesses whom we have examined it would not be an exaggeration to say that 75 per cent. initially favoured the retention of certificates, but that when the scope of the proposed new Act was explained to them, it was almost universally admitted, that insistence on certificates would be useless and impracticable. It is true that this argument is not absolutely conclusive, and it might still be urged that the importance of the certificate is such as to necessitate the inclusion of prime-movers in the Act. It is however necessary to determine :—

(*a*) what qualifications are necessary for a boiler attendant ?

(*b*) what grade of attendant should possess such qualifications ?

Requirements of a Boiler Attendant.

19. The ordinary type of boiler used on land does not consist of complicated mechanism, with the exception of certain tubular boilers which will be considered later. Apart from upkeep and the quality of the water supply, the safe working of a boiler requires a knowledge of three important facts, the level of water, the pressure of steam and the fire which converts the water into steam. The stoking of the ordinary type of boiler does not require theoretical training, and efficient stoking is the outcome not of learning but of experience ; in any case inefficient stoking will not result in a serious accident. To ensure the safety of a boiler it is essential that the water should be maintained at a certain level ; this is indicated in the water gauges. It is accordingly necessary that the gauges should be carefully watched ; this requires care, not learning. Some knowledge of the feed pump is desirable, but in the absence of such knowledge, it is merely necessary to know that, if the water falls below a certain level, the fires must be drawn. The pressure of steam in the boiler is shown on the pressure gauge ; there are ordinarily two safety valves on the boiler, both of which are set by the Inspector to blow off automatically, when the maximum pressure allowable is reached. It is extremely improbable that both the safety valves and the pressure gauge should be out of order at the same time, and it is only necessary that the boiler attendant should know that, if the boiler reaches the maximum pressure, the safety valves will automatically blow off. For the upkeep of a boiler the principal consideration is efficient and sufficient cleaning ; this must depend on the quality of water used, by which the rate at which

scale is formed in the boiler is regulated; accumulation of scale is a frequent cause of accidents to boilers. Such knowledge can only be gained by actual experience of individual plants, and it has been admitted before us that the certificated engineer in India has ordinarily not the requisite knowledge for ascertaining the probable rate of formation of scale by chemical examination of the water used. It has been admitted by all technical witnesses, whom we have examined, that the repair of boilers is a profession in itself and should never constitute part of the duties of the boiler-attendant or engineer. It will thus be seen that the essential requirements of a person-in-charge of a boiler are such as are gained by experience and not by technical training. In the evidence that we have heard the strongest supporters of the certificate system have admitted that they place more reliance on experience than on the possession of a certificate. The above remarks cannot, it is true, be applied to complex types of water-tube boilers; such boilers are, however, used solely in large installations, the value of which is so great as to ensure the retention by the owners of a staff technically capable of maintaining them in a thorough state of efficiency. The necessity of certificated engineers in such cases has not been seriously argued before us.

The anomaly of certificated engineers for large boilers.

20. Accidents to boilers are ordinarily due to two causes:—

(*a*) corrosion or fracture of the plates due to wear, tear and impure water,

(*b*) collapse of furnaces due to insufficient water, or accumulation of scale or other matter.

The first cause is sufficiently guarded against by the present system of inspection; the second cause is one that can be guarded against only by the carefulness of the person in immediate attendance on the boiler. It is an anomaly that, in provinces where certificates are required by law, a certificate is required for the man in immediate charge of a small boiler, while in the case of large boilers the actual work on the boiler may, so far as the law is concerned, be done by the most ignorant coolies, devoid of all experience. In the case of large boilers where first or second class engineers are required, the certificated man is in supervising charge. As a matter of actual practice he is in charge of the boilers and the machinery, and in actual fact, as the evidence has shown conclusively, his attention to the boilers is confined to a few cursory visits to the boiler-house in the course of each day. We have it on evidence that he is seldom, if ever, present at the time when steam is being raised—the time when the occurrence of an accident is the most probable. The certificated engineer is merely a convenience to the owner—a convenience due to the fact that at present there is no other source, from which mechanical engineers, capable of taking charge of machinery, can be obtained. We consider that under the present system of certificates there is no actual safeguard against the occurrence of explosions in large boilers. We have further shown that in the case of large as well as small boilers the essential requirements are such as can only be gained by practical experience—requirements for the existence of which no certificate

can be proof. No examination or certificate can guard against the person in charge falling asleep during his period of duty.

Defects in the training for certificates.

21. The case against the certificated engineer does not, however, stop here. It is doubtful whether the present system of training and examination tends to produce the right type of man—it certainly possesses the damning disadvantage of effectually preventing the illiterate or semi-literate man from ever attaining to the charge of anything but the smallest boiler. We have on the other hand been strongly impressed by the type of engine-driver produced by the Royal Indian Marine and the Indian Railways, a type drawn from this very class which the certificate system effectually prevents from advancement in the charge of other boilers. The present first or second-class engineer is drawn from the educated classes, and in the majority of cases has undergone a course of training in a Technical Institute; we do not wish to enlarge on the obvious defects of such training—the almost complete subordination of practical to theoretical training. It is now possible for a student of the Victoria Technical Institute at Bombay to obtain an engineer's certificate after a few months' practical experience in shops, possibly without the benefit of any practical experience of a boiler. The effect of these certificates on mechanical engineering training may perhaps be outside the sphere of our enquiry, but it is important to note that, although the inducement offered by the certificate may result in increasing the number of students, the fact that the certificate gives a certain means of livelihood has effectually nipped in the bud any aspirations to complete the course in mechanical engineering, and has thus placed a certain check on the outturn of mechanical engineers in the true sense of the term. We do not however put forward this argument as a conclusive proof against the necessity of certificates. Actual experience has proved these conclusions to be well founded; even the strongest supporters of the certificate system have admitted that the product of the Technical Institute is merely an "arm chair" engineer, that he is there to give orders and to fulfil the requirements of the law, but that practical work is beyond his sphere. Other evidence has been still more outspoken and has shown that it is not a rare occurrence for the owner to retain an uncertificated and legally unqualified practical man to attend to his boilers, while a certificated engineer exists in addition on the establishment merely for the purpose of satisfying the requirements of the law.

Discussion of the system of certificated persons in charge.

22. Certain radical defects have already been pointed out in the present system of certificates—such defects are general, but not exhaustive. In the Punjab, for example, the standard of examination has been lowered owing to the failure of a sufficient number of candidates to pass the test. In Bombay the necessity of employing certificated men to hold charge of agricultural boilers has been relaxed in order to avoid the imposition of an excessive

tax on small industries. A further defect was pointed out by the Indian Industrial Commission, that the possession of a certificate gives a fictitious value to its holder and makes it more expensive to employ him on small installations. We are doubtful if there is much force in this contention : it applies, it is true, to the instance of agricultural boilers in Bombay; it applies to instances where an uncertificated man is in actual charge and a certificated man is required in addition to fulfil the requirements of the law; it would also apply in such areas as Assam, where the boiler attendant is ordinarily drawn from the ranks of the ordinary cooli labour, and any increase in salary necessary might result in a general demand for a rise in the scale of wages. In all provinces where the system is in force, however, with the exception of the Punjab, the supply of certificated men is greater than the actual requirements, and this excess of supply effectively limits wages (except perhaps in the case of the requirements of the very smallest installations) approximately to their real market value. It is, however, obvious from the amount of evidence that we have heard in its favour that the system must have certain advantages. These advantages may be summarised as follows :—

(*i*) A certificate is an assurance that a competent person is in charge of the boiler.

(*ii*) A certificate is the only practical test by which the small owner can select a boiler attendant.

(*iii*) The existence of a certificate tends to afford a strong hold over incompetent men.

(*iv*) Boiler engineers of the 1st and 2nd class are capable of supervising other machinery, and their retention is accordingly advantageous to the owner, and finally

(*v*) The certificate relieves the owner of responsibility in case of accidents.

To the first argument we do not under the present system of certificates ascribe much importance; the force of the second we admit, and while realising that the small owner requires some assistance in the selection of a boiler attendant, we do not think the argument sufficiently strong to justify the compulsory possession of a certificate; in paragraph 25 we suggest an alternative. The third argument is reasonable, but the power now existing has very rarely been used in practice, and the advantage to the public safety would not be commensurate with the degree of interference to industrial liberty involved in the system. The fourth and fifth arguments are, however, the meat of the popularity of the system. As regards the former we have only to observe that it is impossible, though perhaps it has been justifiable in the past, to treat a Boiler Inspection Act as a means of securing training in mechanical engineering; we reserve our further remarks for paragraph 25. To the final argument, however, we take the strongest exception. It has been openly and honestly stated before us, on more than one occasion, that the

appointment of a certificated engineer shifts the responsibility in case of an accident from the owner directly to the engineer and indirectly to Government. It does not seem that such a claim has any legal justification; if that were the case, the system of certificates must be condemned root and branch. The engineer, whether certificated or not, is an employee and subject to the orders of the owner. Instances are not rare in which the owner has refused to carry out the advice of a certificated engineer regarding the cleaning or repairing of his boiler, and any decrease in the owner's sense of responsibility must be attended by unfortunate consequences for the development of industry.

Comparison of different types of boiler attendants.

23. It is not easy to assess the respective merits of persons-in-charge of boilers in provinces where certificates are required and in those where the owner is free to make his own selection. It is not safe to rely on statistics of accidents; for there is no assurance of complete or uniform record; but it appears that accidents have been no more frequent in Bengal and Madras than in other provinces. Explosions are so rare in India, that they furnish no ground for comparison. The last explosion of a boiler in Bengal occurred some 10 years ago, the boiler being under the supervision of a skilled European engineer! There has been no evidence to show that the qualifications of boiler engineers and attendants are lower in Bengal and Madras than in the rest of India. In Bengal it is true an original advantage may have been derived from the existence of a large number of European engineers for training purposes. So great however has been the industrial development of other areas recently, that this advantage has now been discounted. In only one province have we been able to obtain comparative evidence on the respective merits of the two systems. In the area of the Punjab notified under the Act, certificates are required; in the remainder of the province they are not. The evidence recorded shows clearly that the men in charge of boilers in the unnotified area are at least no less efficient than their brethren in the notified area—this evidence is supported by the fact that there is no demand for certificated men in the area excluded from the Act. This evidence received very strong support from an officer of the Irrigation Department in the Punjab, who employs men of both categories. The absence of certificates in such unnotified areas and in provinces where certificates are not required appears to have resulted in the training up of a class of boiler attendant of a more practical and suitable nature—the type that is excluded by the certificate rules in other provinces.

Difficulties arising from abolishing the certificate system.

24. It has been maintained that if the necessity of possessing a certificate is abolished, it will be—

(*a*) difficult to find persons competent to take charge of boilers;

(*b*) impossible to provide for the present certificated men;

(*c*) difficult to know the qualifications of men appointed, and

(*d*) customary for owners to employ the cheapest type of labour procurable in areas where certificates are now required.

The first two points are closely connected, but it seems obvious that for several years to come the present supply of certificated men will be available for employment, if they are, as is maintained, really efficient at the work. There is further no reason to believe that a good class of boiler attendant will not be gradually trained up in the rest of India, as has been the case in Bengal and Madras, and, as Sir Alfred Chatterton informs us, in Mysore. In fact we have had evidence to show that such a class already exists in most parts of India; and even in Burma, where the existence of such a class might have been doubtful, evidence was given by two small mill owners that they had in their employment persons fully competent to take charge of boilers, but unable to do so on account of absence of certificates. It has further been maintained that if certificates are dispensed with, it will be necessary to provide, temporarily at least, for such students as are at present under training. We are unable to see the force of this argument; the training referred to is one for mechanical engineering generally; this offers ample scope for the successful student and includes the care of boilers, from which our suggestions do not debar any competent engineer. The third point is one in which we have much sympathy for the small owner; we do not think that it is unreasonable of him to expect a modicum of assistance in selecting men for working boilers, over which Government must insist on a somewhat severe degree of control; our views are stated at greater length in paragraph 25. The fourth argument is one that we cannot endorse; it was argued before us in many places, especially in Bombay, that if certificates were abolished, the small owner would employ the cheapest form of labour available, regardless of its qualifications and of the great expenditure of money that would be involved by the rapid deterioration of the plant; it was consistently maintained, in spite of a somewhat drastic cross-examination, that the small owner would risk the loss of a Rs. 5,000 plant in order to effect a monthly saving of Rs. 20, in his wages bill; it was further maintained that even the experience of actual loss due to inefficient labour would not result in the employment of a superior type of labour. This certainly has not been the experience in areas where certificates are not required by law, and we are not prepared to accept the suggestion that there is so essential a difference in character between the small owner in Bombay and in other parts of India. Bombay in fact has furnished us with an important example, which disproves its own contention. It has already been mentioned that the owners of small agricultural boilers in Bombay are exempted from the necessity of employing certificated attendants; if the Bombay contention were true, it would not be unreasonable to assume that these boilers would be placed in charge of the cheapest labour available. This has, however, not been the case; an inspection of these boilers, undertaken two years after the issue of the orders dispensing with the compulsory employment of certificated attendants, disclosed the fact that in almost every instance a certificated attendant had been retained. In Burma we have had positive evidence placed before us to the effect that in any circumstances the boiler owner would consider first not the cheapness but the efficiency of his labour. There are, we think, no grounds for presuming that abolition of certificates would lead to the employment of an inferior type

of labour, or that the results in Bombay would be in any way worse than they have been in Bengal and Madras.

Compulsory certificates to be abolished.

25. We have not dealt with other aspects of the problem—the immobility of labour arising from the fact that a certificate granted in one province may be inoperative in another; the difficulty is one that could easily be guarded against by unification. The difficulties of the owner in remote areas due to the death, disappearance or illness of the certificated attendant, calamities of no uncommon character, which would necessitate the closing down of the plant, are too obvious to require a detailed description. We admit that a certificate may be of considerable value to the owner if granted as the result of a really practical training; we do not admit that a certificate for a boiler attendant is of such importance, with a view to the prevention of accidents, as to make it compulsory to limit the owner to the employment of certificated men, whatever may be the value of the certificate granted. There is a vast difference in the distinction between compulsory employment in the interests of the public safety and optional employment in the interests of the owner; the latter aspect is one which does not come within the scope of the Act. There is no doubt that the certificate system has been of immense value in the past, when the use of steam machinery was in an embryo stage; it has trained up a class of engineers, many of undoubted efficiency, for whom training would otherwise, in the existing state of training for mechanical engineering, have been impossible. The system of training and examination is however, defective, and, moreover, out of place in a Boiler Inspection Act. We do think, however, that the owner should be afforded an opportunity, if he so desires, of securing men whose qualifications can be known by a diploma or certificate. There is undoubtedly an increasing demand for qualified mechanical engineers. The new Act is not, however, intended to be an educative medium and we would put forward a very strong plea for the urgency of improving the present system of training of mechanical engineers, and of instituting a system that will result in a satisfactory supply, and one that will grant diplomas or certificates to engineering students at different stages in their studies.

Safeguards in the new Act.

26. We accordingly recommend that the provisions of law requiring the employment by owners of boilers of certificated attendants should be repealed, and have accordingly excluded from the draft new Act all references to such certificates. We consider that efficient inspection, in the control of which we suggest considerable improvements, should normally be sufficient to guard against accidents. We have, however, drafted two special provisions, one in the law, the other in the rules, which should result in efficient management of boilers. In the law [section 13 (*b*)] we have entered a provision, already existing in a somewhat similar form in the current Bengal Act, empowering the Chief Inspector to withdraw or refuse to renew any certificate for a boiler, the condition of which is such as to show that it is not in charge of a competent person. In the rules we have drafted provisions requiring Chief Inspectors to issue for the use of boiler owners and attendants a series

of simple special instructions regarding the use and care of boilers; these will be hung up in the boiler house and will remove any excuse of ignorance of what is required for the proper working, care, and upkeep of the boiler.

III.—Proposals for New Legislation.

Important features of proposed new system.

27. In paragraph 10 the lines on which the draft Act has been framed have been indicated; four definite recommendations have already been made; firstly, that prime-movers should be excluded from the Act; secondly, that the provision of law requiring the person in charge of a boiler to possess a certificate should be abolished; thirdly, that steam-pipes should be liable to inspection, and finally that the Act should extend over the whole of every province in India. We have attempted to base the new draft Act so far as possible on the provisions of existing Acts, as adapted to the requirements of the new system that we propose. It is now necessary to describe in some detail the main features of the proposed system, and explain the changes proposed from systems at present in force. The description may be divided under the following heads:—

A.—Definition of a boiler and liability of boilers of different classes to inspection.

B.—System of control and status of inspecting staff.

C.—System of registration of boilers.

D.—Legal provisions for the inspection of boilers.

E.—Accidents.

F.—Appeals.

G.—Omissions from existing Acts.

A.—*Definition of a boiler and liability of boilers of different classes to inspection.*

Definition of a boiler.

28. It has already been noted that, excepting the Boiler Explosions Acts, no English Act attempts to define a boiler; in India on the contrary every province has defined a boiler in its Act, each one in a different way. The resultant differences are greater than might be expected, and it is clearly necessary to lay down some definite principles to regulate the definition of a boiler. An examination of the history of the legislation regarding the inspection of steam boilers shows that it originated in the necessity of exercising control over the use of vessels designed for the generation of steam under pressure; the steam thus generated is ordinarily used as the propelling force for a prime-mover; occasionally, however, it may be used for other purposes, *e.g.*, for steaming wood or for filling a steam container. The original Acts were designed to cover boilers used for industrial or *quasi*-industrial purposes, *e.g.*, vehicular and locomotive boilers. The definitions of boilers have, however, ordinarily been so loosely worded that in application they have included many types of vessels which they were not

intended to cover. In Burma, however, the definition has been expressly amended in order to include steam containers, and so wide is its operation that a large part of the time of the inspecting staff is absorbed in inspecting vessels, from which no serious danger can reasonably be apprehended; in fact so wide is its operation that a blockage in the spout of an ordinary steam kettle would render that utensil liable to inspection under the Act. Under every existing definition, excepting one, the smallest toy boiler would be liable to the provisions of the Act, and in four provinces the child-owner should, under the existing law, possess an engine-driver's certificate. The evidence has strongly supported the view that a definition should be framed to cover the intention of the original Boiler Acts in India and that any wider extension of the scope of the Acts is unnecessary and might tend to be obstructive to industrial freedom. Such a definition would exclude vulcanisers, the internal inspection of which is in any case impossible, autoclaves, digesters, and other forms of steam containers. Only in the case of one class of boiler have doubts been raised regarding the advisability of exclusion under the proposed form of definition, *viz.*, boilers used for heating water for domestic purposes. Such boilers are not ordinarily used for making steam purposely, and the pressure at which they work is ordinarily not higher than atmospheric pressure. In such cases no danger exists, but an instance was brought to our notice of such a boiler in which a 60 foot head of water resulted in a pressure of about 30 lbs. to the square inch—a pressure at which an explosion would cause considerable damage. Such an instance, however, is exceptional, and is, in our opinion, insufficient to justify the inclusion of domestic boilers, the inspection of which would entail a vast increase in the inspection staff, within the scope of the Act. The definition contained in the Bombay Act of 1917, at the passing of which the points raised in this paragraph were fully considered, has accordingly been adopted in the new draft Act with a brief addition to secure the exclusion of toy boilers and other boilers of very small capacity from the provisions of the Act. It should be noted that this definition renders unnecessary—a fact not realised in Bombay—the clause in existing Acts, excluding boilers used exclusively for domestic purposes at atmospheric pressure.

Exclusion of specific classes of boilers.

29. In paragraph 12 we have recommended that all boilers, falling under this definition, should be liable to the provisions of the Act, wherever situated, but have entered a provision in the Act (section 4) permitting the exclusion of specific areas for exceptional reasons. It is now necessary to qualify this general inclusion by referring to certain classes of boilers, the majority of which have been excluded by the provisions of existing Acts.

Draft Section 3(a).

(*i*) *Boilers used upon, or appertaining to, a railway.*—This exclusion follows the provisions of five existing Acts, and differs from the Bengal and Punjab Acts only by excluding stationary, as well as locomotive, boilers. In these provinces, however, stationary boilers are inspected by railway officials, who are appointed Inspectors under the Acts—an empty formality which we condemn in paragraph 30. A very small minority of the witnesses has

attempted to condemn the exclusion of railway boilers from the provisions of the Act, on the ground that it places railway companies in a privileged position. With this contention we cannot agree. The number of boilers used on a railway is so great and the organisation of a railway is such as to necessitate the retention of a special boiler inspection staff, and we are fully satisfied that the inspection work is thorough and efficient; it is further apparent that, were the Boiler Inspection Department to be responsible for the inspection of locomotive boilers, a degree of co-operation would be required to which it would be impossible to attain in practice. Considering the qualifications and organisation of the railway boiler inspection staff, we have no hesitation in making them fully responsible for the inspection of all boilers used upon, or appertaining to, a railway.

Draft Section 3(b).

(*ii*) *Boilers in steam vessels and steamships.*—In recommending the exclusion of such boilers we are merely following the existing practice, and have taken the opportunity to define the nature of such boilers with greater accuracy. It has, however, been brought to our notice that, in the case of certain non-passenger carrying vessels, boilers are not liable to any form of inspection. This is clearly a defect in the Inland Steam Vessels Act, and any remedy required should be obtained by an amendment of that Act. Subject to this qualification it is clear that the provisions necessitating a marine survey are sufficient to dispense with any further inspection by the Boiler Inspection Department.

Draft Section 3(c).

(*iii*) *Boilers under the control of the Royal Navy (including the Royal Indian Marine).*—This proposed exclusion is new. At present such boilers are not liable to inspection under the general exclusion of Government boilers. All boilers on vessels belonging to the Royal Indian Marine are, however, liable to a marine survey, for the purpose of which an expert inspection staff is retained. In view of this fact we propose that the Royal Indian Marine should be made responsible for the inspection of all boilers, both land and marine, under its control.

The majority of the existing Acts contain a specific provision for the exclusion either of such classes of boilers generally, or of such vehicular boilers as the Local Government may specify. This provision appears to be unnecessary now that a definition of a boiler has been framed which can be of general application. The reference to vehicular boilers was necessitated by the existence of boilers of the flash type, such as are used on the White Steam Car; these boilers will be excluded by the provision in the definition excluding boilers of less than 5 gallons capacity. No provision for such exclusions has accordingly been made in the draft Act.

Boilers, the property of the Crown.

30. It has been ruled that none of the existing Acts are applicable to boilers, the property of the Crown. As a matter of fact in certain provinces, *e.g.*, the Punjab and the Central Provinces, Government boilers are considered liable to inspection under the Act, and officers of the

experience, and the actual inspection is made by subordinates, possessed usually of fewer of the necessary qualifications. Such a system is liable to grave abuse and is little more than a means of avoiding the provisions of the Act. It is true that, under very exceptional conditions, we have recommended such a practice in Baluchistan; as a general method of procedure, however, we are of opinion that the practice should be abolished. In provinces where the Act is not considered to apply to boilers, the property of the Crown, it is ordinarily the practice that the Boiler Inspection Department is requested to inspect the boilers; in other cases no inspection is made; while in others a special inspection staff is retained for the purpose. Such a mixture of systems cannot be satisfactory. An instance was reported to us in which some Government boilers were made over to an engineering firm at Karachi for certain war work; the firm requested that the boilers might be inspected before use, but was informed that, being Government boilers, no inspection was necessary. A private inspection by the firm proved that some of the boilers were unfit for use. There is no ground for the supposition that a Government boiler is likely to be subject to more careful or efficient use than one belonging to a private individual, and no reasonable case can be advanced for excluding them from the provisions of the Act. Following the analogy of the Indian Factories Act, we have accordingly framed a section (Section 31), making the Act applicable to boilers the property of the Crown, and in the succeeding section have proposed that the Local Government should exercise the power to suspend the operation of the Act in case of public emergency. We further recommend that all Government boilers should be liable to inspection in the ordinary course by the Boiler Inspection Staff, and that only in very exceptional circumstances, where a department owns a large number of boilers in a compact area, should a special staff be retained by the Department concerned.

Suggested exclusion of other classes of boilers.

31. In framing the Act we have proceeded on the assumption that any boiler working above atmospheric pressure is a dangerous implement regardless of the place where, or the circumstance under which, it is used. Excepting the classes to which specific reference has already been made, little responsible evidence has been produced in favour of the exclusion of other classes of boilers. On the contrary the evidence has proved conclusively the value attached to inspection even in the case of boilers which are under expert control. From the owner's point of view it is stated that inspection keeps the engineer up to the mark and gives the owner a more complete assurance of the work of the engineer; from the engineer's point of view it assists in compelling the owner to undertake repairs which otherwise he might decline to do. In the Punjab and Bombay, however, it was suggested that boilers used for agricultural purposes might be excluded from the operation of the Act on the grounds of difficulties of inspection and the expense to the owner. Practice has, however, proved that difficulties of inspection are exaggerated, and that with the abolition of certificated engineers the cost of inspection is trivial in comparison with the value of the boiler. With the abolition of certificated engineers, moreover, the assumption is that inspection becomes all the more necessary. It must

also be borne in mind that in agricultural areas boilers are less likely to receive adequate supervision, and must deteriorate more rapidly from the use of dirty, or otherwise injurious, water. We are confirmed in this conclusion by the British Board of Trade statistics, which prove that explosions are of most common occurrence amongst boilers used for agricultural purposes. In the Punjab it was further suggested that small boilers of less than 6 or 10 nominal horse-power should be excluded from the operation of the Act. To clinch the argument a witness cited the difficulties of inspection of the boiler of a peripatetic merry-go-round. It would appear, however, that in the instance quoted the position of the boiler is such that an explosion would cause the maximum amount of injury to the greatest number of persons. The argument for exclusion, however, is generally unsound. The explosion of a boiler working at anything above atmospheric pressure may result in extensive damage and loss of life, and it is an indisputable fact that the small boiler generally is under less efficient control and management than boilers of large size. The abolition of any safeguard that may have been provided by the certificated driver renders the necessity of inspection still more imperative. It is true that in the Punjab the definition of a boiler excludes those of less than 50 gallons' capacity. This exclusion is, however, unsound in principle and excludes boilers such as those on fire-engines—boilers over which inspection and control is important.

B.—*System of control of and status of inspecting staff.*

Present system of control by Government.

32. Under the Acts now existing two main systems for the appointment and control of the inspecting staff exist. In the one, control is in the hands of Government which appoints the Inspectors, who accordingly constitute a Government service. The Inspectors are subordinate, either under the Acts, or more ordinarily by rules framed under the Acts, to a Chief or Senior Inspector whose authority is but loosely defined. General administrative control is vested either in the Director of Industries, in the Public Works Department, represented by the Sanitary Engineer as in Madras, or, as in Bombay, in the Collectors of Districts. In paragraph 34 we put forward definite proposals for a revised system of control, and it is only necessary to note briefly the disadvantages of the congeries of sub-systems under the main system of Government control. In the first place, the Chief or Senior Inspector, except in Bombay and the United Provinces, is vested with such shadowy powers that his position is little superior to that of an Inspector; if the uniformity at which we aim is to be anything more than nominal it can only be attained and retained by a system of Chief Inspectors, exercising actual and effective control over the subordinate staff. Control by Collectors is open to even graver condemnation; not only does it connote a complete absence of technical supervision over work of a highly technical nature, but it accentuates the divergences that must result from multitudinous control; in fact to such an extent have we been impressed by the evidence on this subject that, excepting the power to call for a boiler certificate under section 15 of the draft Act, we propose to divest the District Officer of all authority

under the Act. The results of control by the Public Works Department have not impressed us favourably. In Madras, for example, where the work is sufficient to justify the employment of a Chief Inspector and five Inspectors, we find that for some time the strength of the inspection staff has—unavoidably it is true—been reduced to two. Despite this fact, a large proportion of the Chief Inspector's time is absorbed in assisting the Sanitary Engineer in work entirely unconnected with boiler inspection, while the Inspectors are required to inspect water-works plant throughout the province. This must necessarily be to the detriment of boiler inspection work.

Present system of control by Boiler Commissions.

33. Under the other main system of control, the appointment and control of the inspection staff is in the hands of a Boiler Commission, composed of officials and non-officials; this system was initiated under the original Bengal and Bombay Acts of 1864 and 1869. The existing Bombay Act has jettisoned the system, and the Government of Bengal has at present under its consideration proposals for abolishing the Commission, the constitution of which under the Act of 1879 is of doubtful legal validity. Only one other province, namely Burma, has adopted the system which still remains in force in name in that province. The origin of this system was due to the desire to conciliate public opinion at the inception of an Act, which must by its nature be generally unpopular. Under this system, it should be noted, the inspecting staff does not constitute a Government service. In Burma there does not appear to be any particular opinion in favour of the Commission; in fact, as an executive controlling body, it has in practice ceased to exist; the actual control is exercised by the Secretary to the Commission, an officer of the Royal Indian Marine, who now holds a position more analogous to that which we suggest should be held by the Chief Inspector than is held by any officer of the department except in Bombay. In Bengal much of the evidence in favour of the Commission appears to be due to resentment at the strictures made by the Public Services Commission. "The present system", ran the report, "by which in certain places representatives of the interests to be inspected have a voice in the management of the inspection department ... unsound, and should be abolished". Theoretically the correctness of these remarks must be admitted; in practice we need only note that there is not the slightest doubt regarding the fairness and impartiality with which the Commissioners have exercised their control—a result due largely, no doubt, to the value placed by the owner on inspection. At the same time it must be admitted that, while the attitude of the owner-commissioner may be scrupulously fair, the fact that the owner is a commissioner and in control of the inspecting staff may seriously affect the impartiality of the work of the Inspector. Apart from that, however, it cannot be gainsaid that the theoretical objection must prevail. We have, moreover, been impressed by three strong practical objections to the continuance of such Boiler Commissions. In the first place, it is impossible for such Commissions, constituted as they are, to sit continuously. This involves delay; if the Act is to be administered with true regard to the requirements of industry it is essential that decisions and consequent action must be prompt. Secondly, we have been strongly impressed in Bengal

with the poor quality of the work done by Inspectors; this cannot be ascribed to any other cause than lack of real and expert supervision. Thirdly, we feel convinced that the existence of a controlling Commission must so seriously impair the authority and responsibility of the Chief Inspector as to render the position of such an official at least an unenviable one; and so convinced are we of the necessity of raising the status of the Chief Inspector, that we think that this objection alone should prevail. It is unnecessary to criticise the status of the Presidents of the existing Commissions; it can hardly be argued that strong valid objections can exist to the appointment of a non-technical official as the administrative head of a Commission, the whole of which consists of experts. Whether an Indian Civilian stationed at Rangoon, or a Commissioner of Police, whose authority is limited to the town of Calcutta, is a suitable administrator for an Act, which, as we have suggested, should extend over the whole of each province, is a different question; their continuance is an anachronism, dating from the time when the Acts did not extend beyond the towns. The President of the Bengal Boiler Commission advanced before us a spirited defence of the present system; with the greater part of his argument we are in complete agreement. His argument, however, was based on the value of the Boiler Commission as an advisory and conciliatory body, and he referred to cases in which the advice of non-officials, experts and leading men of industry, has been of inestimable value—to cases in which there may be disputes over the interpretation of the regulations or friction between the industrial community and the inspection staff. We trust that disputes over the interpretation of regulations will be avoided by the enforcement of the uniform regulations which we submit with this report; there is no doubt that such disputes in the past have been due to the differences existing between the regulations in force in different provinces and to the fact that the regulations in all provinces are obsolete and do not apply to all existing types of boilers. These causes of dispute we trust we have eradicated. With regard to friction between inspectors and inspected, or other points which it might be invidious for an official to deal with unsupported, we suggest that the Advisory Board of the Director of Industries, or a portion of that Board, would be the correct body to consult. The value of the work of an Advisory Board in this respect cannot be overestimated, and for that reason we would lay especial stress in the importance of placing the Boiler Inspection Department under the control of the Director of Industries.

Proposed system of control.

34. In section 5 of the draft Act we have laid down statutory provisions for the appointment and control of the inspecting staff by the Local Government; in sub-section 3 the subordination of the inspecting staff is subject to the orders of the Local Government. This provision is due to the fact that under the existing scheme of constitutional reform the administration of the Act devolves upon Provincial Governments. The scheme that we propose is a body of Inspectors appointed by Government under the supervision of a Chief Inspector; these appointments are laid down definitely in the Act. We further

propose that the Chief Inspector should work under the administrative control of the Director of Industries. The duties of Inspectors are prescribed in the Act and in the draft regulations and rules framed under sections 27 and 28 of the Act. So far as their duties are concerned no changes of importance are proposed, but the Inspectors are placed more fully under the control of the Chief Inspector, and all powers of making alterations in existing and renewal boiler certificates are withdrawn, and placed in the hands of the Chief Inspector; the reasons for this are so obvious as not to require recital. The alterations in the status of the Chief Inspector are of such importance that we deal with them in a separate paragraph 35. The proposal to place the Director of Industries in administrative control has been generally accepted, except in Madras; we need merely note that the Department of Industries is the one most closely concerned with mechanical engineering, in which boiler inspection plays a most important part, that boiler inspection is most intimately connected with industrial progress, and that the Directors of Industries' Advisory Boards, as has been remarked in the preceding paragraph, are the most suitable bodies for the performance of those important advisory duties, formerly performed by Boiler Commissions, and of such value for the smooth and harmonious working of the Act. The argument was advanced in Madras that the administration of the Act in the past by the Public Works Department through the Sanitary Engineer has been successful, that the Director of Industries is not a mechanical engineer, and that he is in charge of transferred subjects only, whereas the administration of the Boiler Act is a reserved subject. These arguments are, however, not conclusive; that portion of the Public Works Department which controls the Boiler Act has been transferred under the control of a Minister; the Director of Industries, if not himself in the future a mechanical engineer, will be assisted by mechanical engineering advisers and, though we concur in the necessity of technical control in Madras over the Chief Inspector as he exists at present, the improvement that we propose in the status of Chief Inspectors should dispense with the necessity of anything except administrative control. Further, the control of the Sanitary Engineer over the important Boiler Inspection Department must considerably interfere with his own important duties, and has in the past, as we have shown, resulted in burdening the Chief Inspector and Inspectors of Boilers with duties wholly unconnected with boiler inspection. Finally, we cannot concur with the Madras point of view that the administration of the Act by the Public Works Department has been entirely successful; the Madras Boiler Inspection Rules are in part obsolete, in part fundamentally wrong, and their administration has been so inelastic as to result in more difficulties with importers and users of boilers than in any other province. We realise that the administration of the Act must be left to Provincial Governments, but the warning should not be neglected that, where any change in the Act or regulations is required, the opinion of a Provincial Government is not likely to carry the same weight where administration is in the hands of a separate department, as in the case of provinces where the Act is administered uniformly by Directors of Industries and the administration is subject to discussion at periodic conferences.

35. The Public Services Commission recommended that there should be "one officer in each of the larger provinces who should be responsible for the effective working of the inspection staff. He should be called either a Chief or First Inspector according as the work to be done is on a large or small scale". Subject to slight modifications and considerable development, we endorse these recommendations. Action indeed has been taken in name in all provinces in which a Boiler Act is administered, and Chief or Senior Inspectors are now in existence in seven provinces. Their powers and legal authority in most provinces have not however, been defined; their qualifications are rarely sufficient for the duties which we propose to impose on them, while in Bengal and Burma their sphere of activity is closely limited by the existence of Boiler Commissions; in fact in Burma the appointment is purely nominal to meet the suggestions of the Public Services Commission in name. We are very strongly of opinion that, if the uniformity that will be introduced by the new Act and Regulations is to be maintained, a tightening up of the present system of administration is essential. As will be seen in paragraphs 38 and 39, we propose instituting by specific provision of law a new or rather revised system of uniform registration of boilers for the whole of India, which will fix the pressure at which the boiler may be used in any part of India. A perusal of section 8 of the draft Act and of part II, section I of the draft regulations will show that the whole responsibility will rest on the Chief Inspector. If registration is to be uniform the personal equation must be eliminated as far as possible, and the registering authority must be confined to the smallest possible number of persons. We propose that the Chief Inspector should be held responsible for the proper administration of the new Act and regulations; that discovery of defects and proposals for their removal should be a recognised part of his duties; we propose to vest him under section 19 with certain appellate powers—powers only exercised now by the Chief Inspector in the United Provinces; we propose throughout to increase his powers and make him fully responsible for the working of the Act. Our proposals are based on the system at present in force in Bombay—a system far superior in its form and in its results to any other that we have examined. On the Chief Inspector will rest the duty of fixing the maximum pressure of a boiler, of altering the pressure, of deciding complex questions regarding boilers that are below the standard of construction prescribed, of suspending or withdrawing certificates, and other similar important duties. The work which we suggest for him under the Act, regulations, and rules will be a heavy and responsible charge; he will be a supervising and controlling officer, free from all work of actual inspection. We feel that, without the existence of such responsible officers, the efficient and uniform working of any all-India Act and regulations will be impossible. If this decision be accepted it follows that the present average type of Chief or Senior Inspector must go; the post must not be one open to the Inspector in the ordinary course of promotion; it requires special and superior qualifications; it requires officers of a better type and higher status, which will naturally involve the payment of a higher salary. Our terms of reference do not cover the question of the pay or conditions of service of Chief Inspectors, but we

The status of the Chief Inspector.

would put forward the suggestion that, to avoid difficulties regarding pay and promotion and to ensure a greater uniformity in administration, the service should be an all-India one, and Chief Inspectors should be liable to transfer from one province to another.

Chief inspector in the smaller proviences.

36. It may be argued that our proposals are a counsel of perfection, and that in practice the smaller provinces could not afford to pay the salaries required. We have, however, carefully considered this aspect of the problem. It must be remembered that we propose the abandonment of the necessity of employing certificated engineers largely on the grounds that efficient inspection is sufficient to ensure the safety of a boiler. The Chief Inspector will be the keystone of this system of efficiency, and will accordingly be as necessary in the smaller, as in the larger, provinces. We accordingly put forward two alternatives; either in the smaller provinces it will be necessary to impose on the Chief Inspector other duties such as those of Mechanical Adviser to Government, or it will be necessary to form the smaller provinces into groups under the control of a single Chief Inspector; thus Baluchistan might be yoked with Bombay; Assam with Bengal, and Bihar and Orissa with the Central Provinces and Berar; while the United Provinces, the Punjab, Delhi, and the North-West Frontier Province might constitute a single group. Of the two alternatives we favour the latter; under the former it is not improbable that boiler inspection work might suffer at the expense of the other interests of the Chief Inspector, a result which we have already remarked to have been achieved in Madras.

Proposed post of Inspector-General of Boilers.

37. It has been suggested to us that our proposals might prove insufficient to ensure the uniformity, which it is now proposed to introduce into the Act and regulations, and that it might be advisable to appoint an Inspector-General of Boilers for all India. We hardly think that such an appointment would be essential, and it would in any case be inconsistent with the theory of administration of the Act by Provincial Governments. Much must depend on the selection of the right type of man as Chief Inspector, and the assurance would be greater if it were possible to arrange for the transfer of Chief Inspectors between provinces. We are further of opinion that uniformity of administration may be maintained by the discussion of difficulties at periodic conferences of Directors of Industries—provided that all provinces agree to place them in administrative control and, if necessary, by annual conferences of Chief Inspectors. It would, however, lead to facility in subsequent administration if, at the time of the introduction of the new Act, regulations and rules, an experienced mechanical engineer were appointed to advise all Provincial Governments and to assist in the proper initial organisation of the reformed system.

C.—System of Registration of Boilers.

Importance of system of registration.

38. It is clear that some form of registration of boilers is an essential preliminary to an efficient system of inspection. It is prescribed by law in several provinces, and in all provinces a rough method of registration

is in force, ordinarily prescribed by rules framed under the Acts; in no case, however, are the legal provisions sufficient to attain the end that we have in view, and in practice Bombay alone has a system very closely resembling the present proposals. Our main object in insisting on a somewhat complex system of registration is to ensure uniformity in the working of the new Act and regulations throughout India, and to give that uniformity a practical value in the case of boilers which may be used in more than one province. In Bombay a system has been introduced under section 8 of the Act which requires at the time of registration a complete survey and measurement of the boiler, on the basis of which the original maximum pressure at which the boiler may be worked, is fixed. The details and results of this survey are entered in a special memorandum book, which constitutes a test of, and check on, all subsequent inspections. We now propose to develop this system, to amalgamate the original survey and registration into a single process, to be known as registration, and to make the results of this registration in any province valid over the whole of India. The legal basis for registration has been laid down in section 8 of the draft Act; the procedure has been prescribed in the draft regulations, part II, section I, and certain administrative instructions have been formulated in part IV of the rules framed under section 28 of the draft Act. Under section 27 (*d*) of the draft Act the main instructions are contained in regulations to be framed by the Government of India owing to the great importance of maintaining uniformity in registration. It must be remembered that the original inspection of a boiler before use in India differs entirely from subsequent inspections prior to the renewal of an existing certificate. The main object of the original survey or inspection is to ensure that the boiler complies with the standard conditions for the material, design, and construction of boilers; the object of subsequent inspections is to discover whether the maximum pressure permissible as a result of the original survey should be maintained or reduced as a result of deterioration or wear and tear due to bad care and management. It will thus be seen that there is no inconsistency in distinguishing between the original and subsequent inspections.

Outlines of proposed system of registration.

39. Our proposals are briefly as follows: Whenever it is proposed that a boiler shall be used for the first time in India the owner will be required to apply for registration, forwarding with the application certain prescribed drawings and specifications of the boiler. The boiler will then be subjected by an Inspector to a detailed measurement of all its parts; these measurements will be entered in a Memorandum of Inspection Book in a prescribed form in which calculations for the maximum working pressure permissible will be entered. The Memorandum of Inspection Book will then be forwarded to the Chief Inspector for orders under section 8 of the draft Act preparatory to the final fixing of the pressure and the issue of the original certificate. A copy of this book will be retained as a permanent record in the office of the Chief Inspector, while the original book will be maintained as the Inspector's Inspection Book. It will be noted that, with this information at hand, it will be possible to maintain a very close control

over the work of inspection. We further propose that, whenever a boiler is transferred from one province to another, it shall be accompanied by the Registration Book, and for this purpose provisions have been been drafted, necessitating a report of all transfers of boilers, and that any certificate in force at the time of transfer, based initially on such a Registration Book, shall remain in force for the period originally granted, subject only to an examination for the detection of any damage that may have been caused during the period of transit. This system will dispense with new registration at the time of transfer, and will ensure the acceptance in one province of the same maximum pressure that has been allowed in another, thus largely avoiding differences due, apart from differences in regulations, to the personal equation in inspection. It is obvious that the measurements prior to registration require considerably more work and time than the ordinary inspection entails, and we have accordingly proposed that a special scale of fees—higher than those fixed for annual inspections—should be charged for registration. In view of the great advantages which the owner will derive, mainly in case of transfers of boilers, the majority of the witnesses examined have accepted the necessity and justice of this increased scale.

Criticisms of the proposed system.

40. The advantages of this uniform scheme of registration have been almost universally recognised; it will enable the importer to register a boiler at the time and place of import with the assurance that it will be able to work at the pressure then fixed to whatever part of India it may be sent. In the case of the purchase or sale of a boiler, the uniformity of pressure permissible adds a guarantee of great importance to the transaction. Only two objections have been raised against the proposed system. It has been suggested that a thorough examination would still be necessary after the transfer of a boiler on the grounds that an Inspector in the transferring province might be induced to certify a higher pressure than the rules permitted, as his responsibility would then cease, and that damage, hitherto undetected, might come to light when the boiler was unseated. The first ground is based entirely on experience of the system at present in force, and is, we think, sufficiently guarded against by the fact that under our proposals the pressure of a boiler cannot be increased except under the orders of the Chief Inspector, and that the Registration Book maintains a complete and continuous history of the condition of each boiler. In the second ground there may be some force, and accordingly in section 9 (4) of the draft Act we have entered a provision authorising a fresh inspection during the continuance of a certificate. In a commercial transaction this will enable the vendee to insist on the vendor obtaining a fresh certificate for a boiler, after it has been unseated, immediately before the completion of the sale. The other objection raised was to the effect that, where a boiler has been manufactured by a recognised firm of boiler makers, or where a boiler is imported, supported by the certificate of a Boiler Insurance Company, no fresh survey or measurement is necessary. With these contentions we cannot agree. Every Chief Inspector will be responsible for regulating

the working of each boiler at such maximum pressure as will ensure against the occurrence of accidents; if his responsibility is to be complete he must be responsible for the measurements and calculations on which he fixes the maximum pressure. It is an admitted fact that few boilers correspond exactly with the specifications and drawings according to which they are constructed; a difference of $\frac{1}{32}$nd of an inch in the thickness of a plate—a difference that would not be unusual—would result in considerable variations in the calculations; a plate, rolled nominally to the thickness of $\frac{5}{16}$ths of an inch, may not have been evenly rolled. The certificate of an Insurance Company would be of still less value; their ordinary methods of inspection are not in accordance with the regulations that will henceforth be prescribed, nor must it be forgotten that, in the case of a boiler for which the company retains no financial responsibility as in the case of boilers imported into India, the certificate of a company, which exists for the purpose of insurance, cannot be one of sufficient reliability. It is important in our opinion that the responsibility for fixing the maximum pressure should rest on the Chief Inspector.

D.—Legal Provisions for the Inspection of Boilers.

The law relating to inspection of boilers.

41. In the provisions of the draft Act relating to the actual inspection of boilers only two changes in principle have been made. The one change has already been explained in paragraph 34; the Inspector will be authorised merely to renew a certificate without any alteration in the terms thereof; any alterations whether in period or pressure, and any proposals for structural alterations or repairs will require the sanction of the Chief Inspector. The other change proposed is an attempt to reconcile the existing law with present practice. In all existing Acts the Inspector is required by law to inspect a boiler within a certain period from the receipt of the application; the actual periods are as follows:—

Bengal	14 days.
Bombay	4 days or 20 days, if no Inspector has been appointed.
Madras	7 days in the city, 30 days in other areas.
United Provinces	30 days.
Burma	7 days in towns, 21 days in other areas.
Punjab	30 days.
Central Provinces	20 days.

It is *primâ facie* obvious that with inspections extending over the whole of a province it must be impossible, without the entertainment of an abnormal staff, to ensure inspections, boiler by boiler, within the periods fixed. It is further a matter of doubt, what legal responsibility

would attach to the Boiler Inspection Department were an explosion to occur after the expiry of the prescribed period, but before an actual inspection had been made. This method of fixing the period within which an inspection must be made is a survival from the original Boiler Inspection Acts, when the Acts were confined to the towns and it was necessary to exercise strict control over the inspecting staff, which did not constitute a whole-time service. Assuming that a single Inspector is able to inspect from 350 to 400 boilers per annum under present conditions, it would clearly be impossible for him to perform this programme over an area of say, 10,000 square miles, if he were compelled to arrange his programme in the order in which sporadic applications were filed. As a matter of fact, the provision of law is a dead letter in practice. In areas where seasonal factories exist it is obviously essential to inspect either at the close, or just before the commencement, of the working season. In large mills and factories it is important that inspections should be fixed largely to suit the convenience of the owners; in any case it would be impracticable to put a whole battery of boilers out of action for inspection purposes at the same time. As a matter of practice, inspections are now arranged, without any complaints, to suit the convenience of boiler-owners and to facilitate the work of the inspecting staff. It is, however, essential, if no period within which inspection must be made is prescribed, that some provision should be laid down in the Act similar to proviso (*b*) of section 6 (1) of the Bombay Act, to enable a boiler to be used after the expiry of the period of the certificate if inspection cannot be made by the due date. In section 9 (3) of the draft Act we have framed a provision enabling the owner to continue to use a boiler until inspection has been made, provided that he has otherwise complied with the provisions of the Act, and subject to certain conditions under which a certificate would *ipso facto* cease to be valid. No period has been prescribed within which inspection must be made after the date of application, and the responsibility for ensuring systematic and speedy inspection will now rest on the Chief Inspector. The law relating to inspections contains no other changes of importance.

E.—Accidents.

Procedure in case of accidents.

42. In section 2 (*a*) a definition of an accident has been laid down, as under the existing law an accident appeared to exclude an explosion.

No radical alterations have been proposed in the law relating to the report of, or enquiry into, accidents. We have, however, proposed that in the case of serious accidents the enquiry should be in the hands of the Chief Inspector, and have laid down a statutory provision relating to the issue of renewal certificates in case of accidents. We also propose that the law should apply to accidents to steam-pipes as well as to boilers, and have extended the period within which an accident must be reported from 12 to 24 hours in accordance with experience gained from the working of the present law. In section VI of the model rules framed under section 28 of the draft Act a provision has been entered allowing for the enquiring into serious accidents by the Chief Inspector in conjunction with some other person appointed by the Local Government. This proposal

is based on the Commissions appointed to enquire into explosions in the British Isles under the Boiler Explosions Act—a provision of undoubted value in case of serious accidents.

F.—Appeals.

Constitution of appellate bodies.

43. The existing system of appeals differs to a bewildering extent in different provinces. In Bengal the appellate authority constituted by law is a person appointed for the purpose by the Local Government either alone or assisted by two experts as assessors; in practice appeals, if heard at all, are heard by the whole of the Boiler Commission. In Bombay appeals are heard by Commissions consisting of an indefinite number of persons. In Madras the Presidency or District Magistrate constitutes the appellate authority for the area within his jurisdiction with the assistance of two competent assessors. In the United Provinces the Chief Inspector constitutes the first Court of appeal, a further appeal being allowed to the Sanitary Engineer or an officer specially appointed for the purpose, assisted, if he thinks fit, by two assessors. In the Punjab one or more persons may be empowered to hear appeals. Burma relies on a panel consisting of two or more members of the Boiler Commission, subject to a second appeal to the Local Government, while in the Central Provinces each District Magistrate hears appeals, assisted by one or more assessors, a second appeal lying in certain circumstances to the Divisional Commissioner. In actual practice the number of appeals filed is extremely small, one in the Punjab in the past six years and two in Bombay in the last 12 years being typical. It is, however, essential that some provisions should be laid down for the filing and hearing of appeals. The first essential of an appeal under the Act is that it must be decided with the least possible delay; for in most cases in which an appeal would be filed the boiler would remain out of use pending the decision of the appeal. It is accordingly necessary that the system should be one that will ensure a speedy hearing. The second essential is that the appellate body must consist of expert mechanical engineers; for there are few appeals that do not arise from the decision of technical matters and, as the appeal will be against the order of the Chief Inspector—an engineer under the system that we have proposed of special qualifications—it is essential that the appellate body should consist only of the best experts available. In view of the improved status of the Chief Inspector we propose to follow the system in force in the United Provinces and give to the Chief Inspector appellate powers over the orders of Inspectors; in section 19 of the draft Act we have accordingly adopted section 29 of the United Provinces Act with a few verbal alterations. In section 18 of the draft Act powers have been given to Local Governments to constitute an appellate authority for the hearing of appeals against the orders of the Chief Inspector. In view of the different conditions prevailing in different provinces it is probably inadvisable to bind Local Governments absolutely by a provision of law. In part VII of the Model Rules framed under section 28(*f*) of the draft Act, we have suggested a system that should be at the same time expeditious and efficient. In view of the paucity of appeals it is

probable that a single appellate authority would suffice for each province; it is extremely improbable that in any province, except Bombay, mechanical engineers of sufficient status for hearing appeals could be found except near the most important industrial town. We accordingly suggest that a single appellate authority should be constituted for each province except Bombay, where an additional court might be located at Karachi. We suggest that the President of the court should be an officer possessing judicial or magisterial experience, and that the court should consist of three expert mechanical engineers; we suggest the number three in order to avoid requiring the President to give the casting vote, where a difference of opinion may exist, in technical matters of which he is likely to have no knowledge. In order to avoid delay in constituting the appellate court we suggest that each Local Government should constitute a panel of expert mechanical engineers from whom three can be immediately selected at the time of the hearing of an appeal. Witnesses have unanimously accepted the system of appeal which is outlined above.

G.—Omissions from existing Acts.

Important omissions from existing Acts.

44. It is necessary to indicate briefly important omissions from existing Acts which have not been referred to in the report. The Bengal, Madras, and Central Provinces Acts call for no special comment. The only important omission from the Burma and Punjab Acts is the authority given to issue a certificate for a boiler on the report of the certificated engineer without further inspection; this provision is obviously inconsistent with the purport of the Act, and has naturally been excluded with the abolition of the provision necessitating the employment of certificated engineers. From the Bombay Act a considerable amount of detail has been omitted; part of this has been relegated to the regulations and rules; part has been totally omitted as covering details for which no legal provision is necessary. Much the same applies to the United Provinces Act—an Act otherwise admirable. Particular attention is called to provisions in Chapter VII of that Act; section 36 is covered by the provisions of the Indian Penal Code relating to public servants; section 37 appears to enter into much unnecessary detail. In section 47 certain important provisions exist which do not find place in any other Act, namely, the power to extend the Act not only to prime-movers, but to internal combustion-engines, cylinders of vessels used for containing, but not for generating steam, or to any class or description of such machinery. This question has largely been dealt with in this report in discussing the inclusion of prime-movers and the definition of a boiler. It is further obvious that an Act for the inspection of internal combustion-engines, if any considerable danger could be anticipated from them, would necessarily follow very different lines. Such a proposal has not been advanced in any other province, and in our opinion no case has been made out for inserting a provision, making it possible to extend the provisions of the Act to any form of machinery excepting steam-boilers and steam-pipes as defined in the draft Act.

IV.—Proposed new Regulations.

Distinction between regulations and rules.

45. In the preceding paragraph it has been noted that a considerable amount of detail has been relegated to regulations and Rules framed under the Act—provision for this has been made in sections 27 and 28 of the draft Act. As has been previously noted, a sharp distinction has been drawn between the regulations and the rules. The regulations refer entirely to technical matters and to procedure in which homogeneity is essential in order to ensure the uniform working of the Act; these regulations, it is proposed, will be framed by the Government of India; this proposal is unanimously supported by the evidence recorded. The rules refer to questions concerning the administration of the Act; they have been framed as model rules for the guidance of Local Governments, which will have the power to alter them in accordance with the decision that the administration of the Act will be in the hands of Local Governments. The general system on which the regulations and rules have been framed has been described in paragraphs 10 and 11 of this report. It is now necessary to enter into further details regarding the methods which have been employed in drafting them.

Standard conditions for the design and construction of boilers.

46. Part I of the regulations lays down the standard conditions for the material, design, and construction of steam-boilers; these are of fundamental importance; for it is on the basis of these conditions that it is decided whether a certificate can be issued for the use of a boiler and, if so, at what maximum pressure the boiler can be worked. In paragraph 10 we have stated that these standard conditions have been based on the latest Board of Trade Regulations for Marine Boilers, *viz.*, Standard Conditions for the Design and Construction of Marine Boilers, 1920. In adapting these regulations for land boilers in India the evidence of a large number of mechanical engineers has been taken, and a conference of mechanical engineers was also held in Calcutta; the lines on which the regulations have been adapted have followed the decisions arrived at at the conference (*vide* appendix IV) and are supported by most of the technical evidence recorded. It must be remembered that practically all boilers used in India are imported from Europe or America; boilers have, however, been constructed in India from materials imported from abroad, and the construction of a large steel-plate rolling-mill by the Tata Steel and Iron Works at Jamshedpur makes it probable that before long boilers will be constructed in India from material manufactured in India. It has accordingly been necessary to frame the regulations in such a manner as to cover boilers constructed in India from materials manufactured in, or outside of, the country. In order to satisfy ourselves regarding the conditions under which steel plates would be manufactured we visited the Tata Steel and Iron Works. We are satisfied that steel can be manufactured up to the standard laid down in the Board of Trade Regulations; and we are further satisfied that the steel is manufactured under supervision and subject to tests, sufficient to entitle it to most favoured treatment under the regulations. In adapting the Board of Trade Regulations provisions have been inserted to ensure their applicability to land boilers of all types.

47. In appendix I B the proposed standard conditions have been printed with explanatory notes, wherever important differences from the Board of Trade Regulations exist, in order to avoid the necessity of detailed explanations in the report. It is, however, necessary to refer to two matters of importance, the one of form, the other of principle. The former refers to the type of "formula" adopted in the regulations. In all existing provincial rules and in previous Board of Trade Regulations formulæ were recorded in extended form, *i.e.*, in such a manner that each formula was self-explanatory. The new Board of Trade regulations have abandoned this principle and have adopted condensed formulæ, each formula being "boiled down" to the least possible number of ingredients; such condensed formulæ are not self-explanatory, as without detailed calculations it is impossible to estimate how various figures have been arrived at. Provided that the formula is correct, however, there is no necessity that it should be self-explanatory; and the condensed type of formula has the great merit of being clear and brief. We have accordingly adopted the Board of Trade method. The other matter is one of considerable importance. It has been maintained that when once satisfactory standard conditions have been laid down, no new boiler should be licensed for use in India, unless it conforms to these standard conditions. In theory it must be admitted that this argument is correct; in practice, however, it would work with considerable hardship. There is little doubt that, when once a satisfactory uniform standard has been prescribed for the whole of India, there will be a strong tendency for boiler manufacturers to conform to that standard. Instances may, however, occur where a boiler may be imported which in some respects does not fully conform to the prescribed standard, but which could safely be worked at a pressure somewhat lower than the pressure for which it was designed. Following the decision of the Calcutta Conference and the great majority of the evidence, we propose that such boilers should be permitted to be used, but only at such reduced pressure as would be allowed under the conditions that have been laid down in the draft regulations. We would add that in the regulations we have proposed special favourable conditions for boilers that are constructed and the material for which is tested under the supervision and inspection of a recognised inspecting authority. We further propose that the new conditions should not be applicable until one year after the passing of the Act, to allow for the completion of boilers now constructed or under construction.

Explanation of certain points in standard conditions.

48. The general provisions of those parts of the regulations dealing with steam-pipes registration and Inspection of boilers have already been sufficiently described in this report. We propose that the fees for registration of a boiler should be fixed uniformly for the whole of India in the regulations in order to avoid objections that might be raised by importers if a different scale were fixed in different provinces. The fees for inspection will, however, be fixed under the rules by each Local Government, doubtless with regard to the cost incurred in administering the Act. Fees in all provinces are at present fixed on the basis of the

Fees and classification of boilers.

nominal-horse power of the boiler or prime-mover. If the prime-mover is ruled out, it will be found that every province calculates nominal-horse power by a different method, the method being ordinarily based on the area of the fire-grate of the boiler. Thus, while Bombay divides the fire-grate area by $\frac{3}{4}$, Bengal calculates the nominal horse power of a similar boiler by multiplying the fire-grate area by 2. It is obvious that the term "nominal horse-power" has in reality no precise meaning; however important it may have been in the days of Watt, it has no applicability to the modern type of high pressure boiler, and there is accordingly no reason in retaining a term that has become a flagrant misnomer. It is true that the term is still used by certain boiler manufacturers, but instances have been brought to our notice of complaints made by owners of boilers on the ground that the nominal horse-power calculated by the Boiler Inspection Department has differed from that given by the manufacturer. Considering that the term has no real connotation, this is perhaps not surprising! In abolishing this meaningless term we have the support of all the technical witnesses examined. It is still, however, necessary to devise some means of classifying boilers in order to fix the registration and inspection fees for different classes and sizes of boilers; it would clearly be inequitable to mulct the owner of a small vertical boiler in the same fee that is demanded from the owner of a large Lancashire boiler. The fire-grate area of a boiler is not a satisfactory basis as the area can be altered without difficulty. It is essential that the basis for calculation should be simple to enable the owner to file the requisite correct fee in accordance with the Act at the time of his application for registration. We have accepted the principle that the fee should be calculated approximately on the basis of the heating surface—a basis which will approximate to the amount of work involved in inspection. It is not proposed to enter into a minute calculation of the heating surface. In clauses 4 and 5 of section I, part II of the draft regulations the method of calculating the heating surface of different types of boilers—a calculation also required for regulating the areas of safety-valves—has been laid down, and a scale of charges for registration of boilers has been framed, classifying boilers under seven heads on the basis of the area of the heating surface. In order to avoid any misapprehension in the use of the term "heating surface", as in the case of nominal horse-power, we propose to adopt the term "boiler rating". The classification is required for no other purpose except the fixing of registration and inspection fees.

V.—Proposed Model Administrative Rules.

Object of the Model Rules.

49. In paragraph 11 of this report we have indicated the intended application of the model rules to be framed under section 28 of the draft Act, and the manner in which they have been drafted. It is not intended that these rules should be in any way binding on Local Governments, but they will serve to show in what manner the draft Act may be administered, according to the intention with which the Act has

been framed. The rules regarding accidents and appeals have already been referred to in paragraphs 42 and 43 of the report. The remaining rules call for no special comment.

Necessity of efficient staff.

50. In conclusion we would draw attention to a fact which is perhaps not strictly within the scope of our duties. Whatever system may be introduced for the purpose of improving the effects of inspection, whatever Act may be framed for the purpose of enforcing that system, success cannot be expected unless the staff employed is capable of performing the duties assigned to it. Special stress has been laid on the necessity of employing Chief Inspectors possessing special qualifications. But the necessity of employing efficient Inspectors is no less important. Many provinces are at present unable to recruit up to the required strength because they are unable to attract men possessing the requisite qualifications on the salaries that they are prepared to offer. In one province at least the evidence tends to show that the exiguity of the salary offered has resulted in increased, though unsanctioned, charges on the boiler owner. In most provinces the department has been run at a profit; this is not the object of the Act, and the profit might with advantage be used for improving the emoluments of the inspecting staff. If that were insufficient, no objection would be raised to a small increase in the scale of charges. There are only two points to keep in view—the employment of an efficient staff, and the preservation of the fair name of the department.

F. D. ASCOLI, *President.*

D. R. MACINTOSH. } *Members.*
D. B. MANN. }

The 10th March 1921.


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APPENDICES.


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APPENDIX I-A.

A Bill to consolidate and amend the law relating to Steam Boilers in India.

Preamble.

Whereas it is expedient to consolidate and amend the law relating to Steam Boilers; it is hereby enacted as follows:—

Short title.

1. (*1*) This Act may be called the Indian Boilers Act, 1921.

Extent.

(*2*) It extends to the whole of British India, including Baluchistan and the Santhal Parganas.

Commencement.

(*3*) It shall subject to the provisions of section 7 come into force on the first day of .....1921.

The proviso is necessary for the administration of the Act. The period of grace before enforcing the Regulations will be entered in the Regulations.

Definitions.

2. In this Act unless there is anything repugnant in the subject or context:—

New, but necessary; in the former Acts accidents appear to exclude explosions by mistake.

(*a*) *Accident* includes an explosion of or any damage to a boiler or steam-pipe which is calculated to weaken the strength thereof or to cause it to be liable to explode.

The Bombay definition; this definition does away with the clause excluding boilers used for *domestic purposes at atmospheric pressure*—a fact not previously realised in Bombay. The definition is explained in the report. The limit of 5 gallons is entered in order to exclude toy boilers from the operation of the Act and to exclude small boilers of the flash type.

(*b*) *Boiler* includes any closed vessel exceeding five gallons in capacity used expressly for generating steam under pressure for use outside such vessel and any mounting or other fitting attached to such vessel which is wholly or partly under pressure when steam is shut off.

(*c*) *Inspector* means any person appointed under this Act to be an Inspector.

The Bombay and most complete definition.

(*d*) *Owner* includes any person using a boiler as agent of the owner thereof, and any person using a boiler which he has hired or obtained on loan from the owner thereof.

(*e*) *Prescribed* means prescribed by regulations or rules framed under this Act.

New; required by the exclusion of prime-movers and the decision to apply the Act to the inspection of steam-pipes.

(*f*) *Steam-pipe* includes only the main pipe or pipes through which steam passes directly from a boiler or boilers to a prime-mover or other first user.

Limitation of application.

3. Nothing in this Act shall apply to any boiler or steam-pipe—

(*a*) used upon or appertaining to any railway within the meaning of that word as defined in section 3, clause 4 of the Indian Railways Act, 1890;

Central Provinces [3(*a*)], Bombay (2), Madras [1(4)], United Provinces [45(*a*)], Burma [1(4)], Distinguish Bengal (1) and Punjab [1(3)] which excludes only locomotive boilers on railways.

(*b*) in any steam vessel as defined in section 5, clause 2 of the Inland Steam Vessels Act, 1884, or in any steamship as defined in section 3, clause 1 of the Indian Steamships Act, 1884.

This is mainly a new and more precise draft of the old rules.

(*c*) under the control of the Royal Navy.

New; Naval (including Royal Indian Marine) Marine boilers are not covered by the Acts referred to in 3 (*b*) (*vide* sections 67 and 5, respectively). As the Royal Indian Marine has an expert boiler staff all boilers under its control should be excluded.

Exclusions.

4. The Government of India may by notification in the *Gazette of India* exclude any local area from any or all of the provisions of this Act.

This was not required before as former Acts usually referred to notified areas only. For reason *vide* report.

Appointments.

5. (*1*) A Local Government may at any time appoint such persons as it thinks fit to be Inspectors under this Act, and shall appoint one of such Inspectors to be Chief Inspector.

The important point is the legal position of the Chief Inspector, *vide* United Provinces [3(1)], Bombay [4(1)]. The appointment is now made compulsory.

Powers.

(*2*) The persons so appointed shall, within such area as the Local Government may direct, exercise the powers conferred and perform the duties imposed on Inspectors by or under this Act or by regulations or rules framed under sections 27 and 28 of this Act.

Vide Madras [3(2)], United Provinces (5), Punjab [3 (2)].

Status.

(*3*) Every Inspector shall be deemed to be a public servant within the meaning of the Indian Penal Code, and shall be officially subordinate to such authority as the Local Government may prescribe by rule in this behalf.

Adopted from the Factories Act [4(6)]. This dispenses with special provisions regarding penalties for obstructing, etc., an Inspector in the discharge of his duties.

Inspector may enter building.

6. An Inspector may at any time, within the local limits for which he is appointed, enter any place or building where he has reason to believe that a boiler is being used for the purpose of inspecting or examining such boiler and any steam-pipe attached thereto, or of seeing that the provisions of section 7 are being observed in respect of the boiler.

Vide Factories Act [5(*a*)] and Bombay [18(1)], Bengal (10), Madras (13), Punjab (13), Burma (17), United Provinces [7(*a*)], Central Provinces (13(1)]. The section has been modified to some extent.

Prohibition of use of boiler.

This section has been considerably strengthened in view of the change in the method of registering a boiler, 7 (*b*) is quite new to cover transfers (*vide* report). 7 (*a*) is now explicit. *Vide* Bombay 6 (1), United Provinces (10), Punjab 5 (1), Burma (6), Madras 4, Bengal 5, Central Provinces 4 (*a*). The provisos are new and are necessary for the administration of the Act. See also section 1(3) of this draft Act.

7. The owner of a boiler shall not use the same or permit the same to be used—

(*a*) unless it has been duly registered in accordance with the provisions of this Act ;

(*b*) if it has been transferred from one province to another until the transfer has been reported in the prescribed manner ;

(*c*) unless a provisional order or a certificate authorising its use has been granted and is in force under the Act ;

(*d*) at a pressure higher than what is entered in a provisional order or certificate still in force ;

United Provinces 7 (*e*).

(*e*) if it has been declared by an Inspector to be in a dangerous condition while a certificate is in force.

Provided that any boiler registered, licensed or certified under any Act entered in schedule I shall be deemed to have been registered or certified under this Act ;

Provided further that, in any local area in which registration or a certificate or license for the use of a boiler has not previously been required by law the provisions of this section shall not be in force until 12 months after the passing of this Act.

Boiler to be registered.

This section is largely new and is based on the distinction now drawn between original registration and renewal of certificates, but see Bombay 8.

For 8 (1) *vide* Bombay 8 (1) and (2), Central Provinces, 5 (1) and (2), Madras 5 (1), Burma 7 (1), Punjab 6 (1), United Provinces, 11 (1) and (2).

8. (*1*) The owner of any boiler, if he desires to use the same, shall, if it is unregistered, apply to the Inspector to have the same registered. Every such application shall be accompanied by such fee as may be prescribed.

Examination of boiler.

Madras 5 (2) and (3), Burma 7(2) and (3), United Provinces, 11 (3) and (4), Punjab 6 (2) and (3).

(*2*) The Inspector shall after giving due notice under section 10 proceed to measure and examine such boiler and determine at what maximum pressure, if any, such boiler may be used in the prescribed manner and shall report the result of his examination in the prescribed form to the Chief Inspector.

Orders of Chief Inspector.

(*3*) The Chief Inspector may —

(*a*) refuse to register the boiler or permit it to be used absolutely, or until such alterations or renewals as he may direct have been made to such boiler ;

(*b*) register the boiler and assign to it a registry number subject to any alterations or renewals to such boiler that he may deem necessary;

(*c*) order the issue of a certificate in the prescribed form authorising the use of such boiler for a period not exceeding 12 months at such maximum pressure as he may think fit.

(*b*) *Vide* Bombay 8 (2), Central Provinces 5 (2), Madras (9), United Provinces 11 (2).

(*4*) The Inspector shall forthwith convey the orders of the Chief Inspector in writing and issue any certificate ordered under section 8 (*3*) (*c*) to the owner of the boiler, who shall within the prescribed period cause the registry number to be permanently marked on such boiler in the prescribed manner.

Registration of boiler.

Bombay 8 (2), Central Provinces 5(3), Madras (9), United Provinces 11 (2).

9. (*1*) Any certificate granted under the preceding section or any renewal certificate granted under the provisions of section 11 shall be valid only for the period mentioned in the certificate: provided that

(*a*) when any accident has occurred to a boiler or steam-pipe attached thereto as described in section 17;

(*b*) when any boiler, not being a portable or vehicular boiler, has been moved; or

(*c*) when any structural alterations, additions or renewals have been made to any boiler, or steam-pipe attached thereto;

the certificate shall be deemed to be no longer in force until the boiler or steam-pipe has been examined by the Inspector and certified for such period and maximum pressure as he may deem fit.

Limitation of validity of certificate.

Conveys the meaning of all existing Acts but the proviso is mainly new, though essential. Bombay 9, United Provinces 14 and 11, Burma 7, Punjab 6, Central Provinces 6.

(*2*) The owner shall on or before the date of expiry of a certificate, or as soon as a certificate is deemed under the preceding subsection to be no longer in force, apply to the Chief Inspector for a renewal certificate. Such application shall be accompanied by the prescribed fee.

Owner to apply for renewal of certificate.

Is in accordance with existing Acts.

(*3*) Whenever the period of a certificate has expired the owner shall, provided that he has complied with the conditions of section 9 (*2*) and subject to the provisions of section 9 (*1*), be permitted to use the boiler at the maximum pressure entered in the former certificate, pending the issue of or the refusal to issue a new certificate or the grant of a provisional order under section 12.

When certificate to remain in force.

Is most important to cover any delays that must occur in inspection, *vide* Madras 4.

This clause is new and is intended to provide for the not infrequent case of an owner requiring a fresh certificate before the expiry of the old one, *e.g.*, at the time of sale or insurance, etc., *vide* United Provinces 44 and Burma 20.

(*4*) Nothing in this section shall be deemed to prevent an owner from applying for the examination of a boiler and the issue of a renewal certificate therefor at any time during the currency of an existing certificate subject to the cancellation of such existing certificate.

Date to be fixed for examination of boiler.

Vide Bombay 10, Madras 5, Bengal 5, Punjab 6, Central Provinces 4 and 8.

10. (*1*) Whenever an application has been received under section 8 (*1*) or section 9 (*2*) the Inspector shall fix a date for the examination of the boiler, and shall give the owner thereof at least 4 days' notice of the date so fixed.

Arrangements to be made by owner.

The details have been transferred to the regulations.

(*2*) On the date so fixed the owner of the boiler shall—

(*a*) afford to the Inspector all reasonable facilities for such examination and all such information as may reasonably be required of him ;

(*b*) arrange that the boiler is properly prepared for examination in the prescribed manner ;

(*c*) provide in the case of a boiler about to be registered such drawings, specifications, and certificates as may be prescribed.

When examination to be refused.

(*3*) If the owner fails without reasonable cause to comply with any of the provisions of the preceding sub-section the Inspector shall refuse to make the examination and shall report the facts to the Chief Inspector who shall, unless sufficient cause to the contrary be shown, require the owner to file a fresh application and fee under section 8 (*1*) or 9 (*2*), as the case may be, if he intends to use the boiler. In such cases the provisions of section 9 (*3*) shall cease to apply.

Issue of certificate.

Madras 5, 7 and 8, Bengal 6 and 7, Bombay 11, United Provinces 12, Burma 9, Punjab 8.

11. (*1*) The Inspector shall on the date fixed examine the boiler in the prescribed manner and, if he is satisfied that such boiler and the steam-pipe attached thereto are in good condition, shall issue a renewal certificate therefor in the prescribed form for such period not exceeding 12 months and for such maximum pressure, as he thinks fit, in accordance with regulations framed under this Act, provided that if the Inspector intends—

Vide Madras 6.

(*a*) to issue a certificate for a lesser period than that applied for (not being more than 12 months) ;

(*b*) to increase or reduce the maximum pressure admissible ;

Vide United Provinces 16, Burma 8, Punjab 7.

(*c*) to order any structural alterations, additions, or renewals to be made to the boiler or steam-pipe, he shall, within 48 hours of his examination, inform the owner in writing of his reasons therefor, and shall not issue a certificate until he has obtained the orders of the Chief Inspector.

(2) If in the opinion of the Inspector the boiler is not fit for use he shall, within 48 hours of his examination, inform the owner of the boiler in writing, stating his reasons therefor, and forthwith obtain the orders of the Chief Inspector under section 13.

Refusal of certificate.

United Provinces 13.

12. (1) In the case of a boiler in respect of which no certificate has previously been granted, or in respect of which any structural alterations, additions, or renewals have been made or have been ordered to be made or in respect of which it is proposed to increase or reduce the maximum pressure permissible under section 11, the Inspector may, subject to the general orders of the Chief Inspector, within 48 hours next after his examination, grant to the owner a provisional order in writing, permitting the boiler to be used at such maximum pressure as he may think fit, pending the receipt of orders for the issue of or the refusal to issue a certificate from the Chief Inspector.

Issue of provisional order.

Bombay 6 (*iii*) (*a*).

(2) Such provisional order shall be in force for a period not exceeding 6 months and shall be surrendered by the owner on receipt of the Chief Inspector's orders.

Surrender of provisional order.

13. The Chief Inspector may refuse to renew or may withdraw or revoke any certificate on the report of an Inspector, or otherwise—

Revocation of certificate.

Madras 11, Bengal 8, Bombay 17, United Provinces 15, Burma 13, Punjab 11, Central Provinces 12.

(*a*) if there is reason to believe that it has been fraudulently obtained or granted erroneously or without sufficient examination ;

(*b*) if the boiler in respect of which it has been granted has sustained injury or has ceased to be in good condition, or is not in charge of a person competent to have charge of it.

14. No structural alterations, additions, or renewals shall be made to any registered boiler or steam-pipe unless such alterations, additions, or renewals have been sanctioned in writing by the Chief Inspector. The subsequent use of any such boiler or steam-pipe shall be subject to the provisions of section 9 (1) (*c*) : provided that, where such alterations, additions, or renewals are of a petty nature, the Chief Inspector may dispense with the fee required by section 9 (2).

Alterations and renewals to be sanctioned.

Vide United Provinces 26, Madras 10 (3), Central Provinces 14 and Bombay 19.

15. The owner of any boiler who holds a provisional order or certificate therefor shall at all reasonable times during the period for which such order or certificate is in force be bound to produce the same when called upon to do so by a District Magistrate or Commissioner of Police or an Inspector, or an Inspector appointed under the Indian Factories Act, or by any person specially authorised in writing by a District Magistrate or Commissioner of Police.

Production of provisional order or certificate.

Bombay 21 (1), Madras 10 (1), Central Provinces 16 (1), United Provinces 17.

Transfer of provisional order or certificate.

Bombay 21 (2), Madras 10 (2), Central Provinces 16 (2).

16. Any person who becomes the owner of a boiler during the period for which a provisional order or certificate therefor is in force shall be entitled to receive the provisional order or certificate from the preceding owner.

Report of accidents.

Bombay 20, Madras 10-A, Burma 10 (1), United Provinces 28 and Central Provinces 15.

(Time for report altered.)

17. (*1*) If any accident occurs to a boiler or steam-pipe the owner or person in charge thereof shall, within 24 hours of the occurrence thereof, report the same in writing to the Inspector. Every such report shall contain a true description of the nature of the accident and of the injury thereby caused, sufficient to enable the Inspector to judge of the gravity of the accident.

Information regarding accidents to be given.

Follows United Provinces exactly.

(*2*) Every person shall be bound to answer truly, to the best of his knowledge and ability, every question put to him in writing by the Inspector as to the cause, nature and extent of the accident.

Conditions for issuing certificate after accident.

New; it is important that there should be a definite rule about certificates in such cases. For the proviso *vide* the Report.

(*3*) No certificate shall be renewed or granted for such boiler under section 11 until such renewals or repairs as may be ordered by the Inspector have been carried out, provided that—

Whenever an explosion has occurred, or whenever in the opinion of the Inspector the accident is of a serious character, he shall report the facts to the Chief Inspector, and no renewal certificate shall be granted without the orders of the Chief Inspector.

Constitution of appellate authority.

Bombay 5.

18. The Local Government shall constitute by rules framed in this behalf an appellate authority for hearing appeals preferred by owners under section 20.

Appeals to Chief Inspector.

United Provinces 29.

Vide Report.

19. Any person considering himself aggrieved by—

(*a*) an order made or purporting to be made by an Inspector in the exercise of any power conferred by this Act or by any regulation or rule made under this Act; or

(*b*) a refusal by an Inspector to pass an order which he is required or entitled by this Act or by any regulation or rule made under this Act to make,

may, within 30 days from the date when such order is served upon him or such refusal is communicated to him or purports to have been made, appeal against such order or refusal to the Chief Inspector, whose decision, except as provided in the next succeeding section, shall be final.

Appeals to appellate authority.

Bombay 14, Madras 12, Bengal 9, United Provinces 31 and 32, Burma 16, Punjab 12, Central Provinces 9 and 10.

20. Any person considering himself aggrieved by an order of the Chief Inspector, whether in original or in appeal,

(*a*) refusing to register a boiler or to grant or renew a certificate to the owner of a boiler,

(*b*) refusing to grant a certificate for the full period applied for (not being more than 12 months) or for the maximum pressure desired,

(*c*) withdrawing or revoking a certificate,

(*d*) reducing the amount of pressure specified in any certificate or the period for which such certificate has been granted,

(*e*) ordering structural alterations, additions, or renewals to a boiler or steam-pipe

may within 30 days of the receipt of such order lodge with the Chief Inspector an appeal to be heard by the appellate authority constituted under section 18. The decision of the appellate authority shall be final.

21. Orders in appeals under sections 19 and 20 shall be communicated to and executed by the Inspector concerned and the Chief Inspector, respectively.

Execution of orders in appeals.

This section has been inserted in order to cover apparent difficulties that have been experienced in executing orders in appeals.

22. Any owner of a boiler who—

(*a*) makes any structural alterations, additions, or renewals to a boiler or steam-pipe without the orders of the Chief Inspector as required by section 14,

(*b*) refuses or neglects to produce a certificate when duly called upon so to do under section 15,

(*c*) refuses or neglects to surrender a provisional order as required by section 12 (*2*),

and any person who –

(*d*) refuses or neglects to make over to the new owner of a boiler a provisional order or certificate as required by section 16,

(*e*) tampers with a safety-valve of a boiler so as to render it inoperative or causes it to be loaded over the pressure entered in a provisional order or certificate in force for the boiler,

and every owner or person in charge of a boiler or steam-pipe who—

(*f*) fails to report an accident to a boiler or steam-pipe as required by section 17,

(*g*) or fails in any case to disconnect a boiler when any person is examining it or working therein in accordance with regulations framed under section 27 (*g*),

shall be punishable with a fine which may extend to Rs. 100 for each offence.

Penalties for single offences.

Madras 21, Bengal 11, Bombay 31, 32, United Provinces 34, Burma 18, Punjab 14, Central Provinces 18 and 19.

Penalties for continuing offences.

Madras 21, Bengal 11, Bombay 31 and 32, United Provinces 34, Burma 18, Punjab 14, Central Provinces 18 and 19.

23. Any owner of a boiler who uses the same or permits it to be used :—

(*a*) without a provisional order or certificate duly obtained and in force in respect thereof,

(*b*) at a higher pressure than that allowed by a provisional order or certificate in force in respect thereof,

(*c*) without reporting the transfer thereof from one province to another as required by section 7 (*b*)

shall be punishable with a fine which may extend to Rs. 500 and in the case of a continuing offence, with an additional fine which may extend to Rs. 100 for every day after the first in regard to which he is convicted of having persisted in the offence.

Penalty for tampering with registry mark.

Bombay 34, United Provinces 35, Central Provinces 20 and 21.

24. (*1*) Whoever removes, alters, defaces, renders invisible or otherwise tampers with a registry number marked on a boiler shall for every such act be punishable with a fine which may extend to Rs. 500.

(*2*) Whoever fraudulently marks upon a boiler a registry number which has not been duly allotted to it under the Act shall be punished with imprisonment which may extend to 2 years or with fine or with both.

Limitation of charges.

Madras 22, Bengal 12, Bombay 37, United Provinces 40 and 39, Burma 19, Punjab 16, Central Provinces 24.

This section follows existing practice as adapted to the proposed system.

25. No charge shall be brought against any person of any offence punishable under this Act except within 12 months after the commission of the offence, nor shall any such charge be brought without the sanction of the Chief Inspector.

Offences by whom cognisable.

Bombay 36, United Provinces 39(2), Central Provinces 23.

26. No offences against this Act shall be cognisable except by a Presidency Magistrate or a Magistrate of the first class.

Issue of regulations.

Madras 23, Bombay 38, United Provinces 41, Burma 21, Punjab 17, Central Provinces 25.

27. The Governor-General in Council may, by notification in the *Gazette of India*, issue regulations consistent with this Act for all or any of the following purposes :—

(*a*) for prescribing the technical duties of the Chief Inspector and Inspectors ;

(*b*) for laying down standard conditions for the material, design and construction of boilers ;

(*c*) for determining the maximum pressure at which a boiler may be used ;

(*d*) for regulating the registration of boilers, including the fee payable thereon, the drawings, specifications and certificates to be produced by the owner, the method of preparing a boiler for examination,

the form of the inspector's report, the method of marking the registry number, and the period within which such registry number must be marked on the boiler;

(*e*) for regulating the inspection and examination of boilers and steam-pipes, and prescribing forms of certificates therefor;

(*f*) for prescribing the material to be used for the construction of steam-pipes;

(*g*) for ensuring the safety of persons working inside a boiler;

(*h*) generally for the registration of boilers and the technical requirements of the Act.

(*g*) has been added to allow of provisions similar to Section 10(2) of the Bombay Act.

28. A Local Government may, by notification in the official Gazette, issue rules for all or any of the following purposes:—

Issue of rules.

Madras 23, Bombay 38, United Provinces 41, Burma 21, Punjab 17, Central Provinces 25.

(*a*) for prescribing the administrative duties of Chief Inspector and Inspectors, their salary, allowances and conditions of service, and the administrative control to be exercised over them;

(*b*) for regulating the transfer of boilers;

(*c*) for regulating the administration for registering and issuing certificates for boilers;

(*d*) for prescribing fees for the issue of renewal certificates, and the method of determining such fees;

(*e*) for regulating enquiries into accidents;

(*f*) for constituting the appellate authority under section 18, its powers, the method of hearing all appeals and for levying costs in appeals;

(*g*) for the method of payment and disposal of all fees, costs and penalties levied under the Act;

(*h*) generally for carrying out the administration of the Act.

29. All regulations and rules made under sections 27 and 28, shall be made after previous publication, and when made shall be finally published in the Gazette, and shall come into force on such date as may be specified therein.

Regulations and rules to be published.

Burma 21.

30. All fees, costs and penalties levied under this Act shall be recoverable as public demands, and shall be disposed of in such manner as the Local Government may direct.

Recovery of fees, etc.

Vide Bengal 13, Bombay 39, Central Provinces 26.

Public demand has been adopted in place of "arrears of land revenue."

31. This Act shall apply to boilers and steam pipes belonging to the Crown.

Applicability to the Crown.

Factories Act, Section 54.
Vide Report.

Power to suspend in case of emergency.

Factories Act, Section 56
Vide Report.

32. In case of any public emergency the Local Government may exempt any boiler or steam-pipe from this Act to such extent and during such period as it thinks fit.

Repeals.

Vide Factories Act, Section 59.

33. The Acts entered in Schedule I are hereby repealed, provided that all appointments made and all certificates given under the said Acts shall be deemed to have been made or given under this Act.

SCHEDULE I.

Act.

The Bombay Boiler Inspection Act (V of 1917) as amended to date.

The Bengal Steam Boilers and Prime-Movers Act (III of 1879) as amended to date.

The Madras Steam Boilers and Prime-Movers Act (III of 1893) as amended to date.

The Punjab Steam Boilers and Prime-Movers Act (II of 1902) as amended to date.

The Burma Steam Boilers and Prime-Movers Act (II of 1910) as amended to date.

The United Provinces Steam Boilers Act (III of 1915) as amended to date.

The Central Provinces Boiler Inspection Act (II of 1907) as amended to date.


सत्यमेव जयते

APPENDIX I.-B.

Regulations framed by the Government of India under Section 27 of the Indian Boilers Act.

ACT NO. OF 192


सत्यमेव जयते

PRELIMINARY.

1. The following regulations for the inspection of land boilers and main steam pipes in British India, and for their material, design and construction, shall be applicable to all boilers registered after the first day of.....

Boilers registered before that date under the various Acts, and boilers in areas excluded from the operation of such Acts on that date, shall, as they stand, be deemed to comply with these regulations.

2. In Part I Inspector means, for material manufactured or boilers constructed, (*a*) in British India, an Inspector appointed by Government for the purpose, (*b*) outside British India an Inspector acting on behalf of any Inspecting Authority recognised as competent by the Government of India.

Part I.—Standard conditions for the design and construction of land boilers.

SECTION I.—GENERAL REQUIREMENTS AND CONDITIONS AS TO MATERIAL, WORKMANSHIP, ETC.

1. *Standard Requirements. Material.*—All steel plates, rivets and bars, used in the construction of boilers must be tested and found to conform to the requirements of Section II.

Construction.—All boilers during construction shall be under the supervision of an Inspector.

Inspector's certificate.—For boilers imported into British India a certificate from an Inspecting Authority certifying that the material was tested and the boiler built under their supervision shall be furnished to the Chief Inspector before or with the application for registration. In the case of steel made and tested by well known makers in India or Great Britain, the certificate of the makers as prescribed in Clause 16 of Section II will be accepted in lieu of one from an Inspecting Authority.

Makers' Certificates under Section 10 (2) (c) of the Act.—The following certificates shall be furnished to the Chief Inspector before or with the application for registration :—

(*a*) a certificate of manufacture and test from the maker of the boiler containing a description of the boiler, its principal dimensions, particulars of the kind of material used in its construction, the thickness of all plates, the diameter of and method of forming the rivet holes in the shell plates, particulars of any departure from ordinary practice in making the shell such as solid rolling or welding, the hydraulic test to which the boiler was subjected, the intended working pressure, the year and place of make, and the works number of the boiler ;

such certificate must be signed by the maker or a responsible representative at the works.

(*b*) a fully-dimensioned drawing or print showing a longitudinal section and end view of the boiler, and bearing the works number of the boiler and the maker's office stamp ;

(*c*) a certificate or certificates from the steel maker and the maker of the plates, rivets or bars in accordance with Clauses 15 and 16 of Section II. The certificate of the maker of the plates, rivets or bars, must show the dimensions of the various plates, etc., tested, together with their number and the number of the charges from which made, the dimensions of the test pieces, their ultimate tensile breaking strength in tons per square inch of section, the percentage of elongation and the length on which measured, the number, kind and result of bend or other tests made and the date of tests.

Maker's stamp.—The boiler shall have stamped upon its front plate in a conspicuous position the following particulars:—

MAKER'S NAME.	
Works' number	Year of make
Tested to.....lbs.	on.....
W. P.....lbs.	Inspector's initials or stamp of Inspecting Authority.

2. *Boilers not complying with Standard Requirements.*—Boilers not fully complying with the Standard Requirements may, with the approval of the Chief Inspector, be allowed to work at a lower pressure than would otherwise be permitted, but no structural part of a boiler made of Bessemer process steel or of cast or malleable cast iron shall be accepted.

Modification of Formulæ.—Under the Regulations for determining the working pressure to be allowed on various parts of boilers, the material (except where specifically indicated) to which the formulæ apply is steel complying with the requirements of Section II.

Where steel of a lower tensile breaking strength than the minimum required under Section II is employed, such minimum tensile breaking strength shall be used as S in the formulæ for determining the working pressure. Where end plates, furnaces, flat plates, gusset and other stays, etc., are made of steel or iron for which no test certificates are produced, the working pressure as found from the formulæ, reduced by 16 per cent. shall, except where such material is specifically provided for in any formula, be the working pressure permitted.

For flat plates of copper, the working pressure as found from the formulæ, reduced by 50 per cent. shall be the working pressure permitted.

3. *Standard Specifications for Material.*—Standard specifications for steel, wrought iron and copper plates and bars, and for cast steel for firebox girders are prescribed in Section II, but certificates of tests of material for wrought iron (except for special wrought iron for screw stays) copper and cast steel need not be produced unless special allowances are required. Such special allowances shall be in the discretion of the Chief Inspector.

4. *Welded Steel plates.*—No steel plates subject to a direct tensile stress are to be welded, except where the weld is covered by a butt strap or straps or except where specifically permitted in the Standard Conditions.

From Board of Trade "Standard Conditions".

5. *Annealing after working in fire.*—All steel plates which are welded, dished, flanged or locally heated are to be afterwards efficiently annealed.

From Board of Trade "Standard Conditions".

6. *Rivet Holes.*—All rivet holes must be drilled "fair" and as far as possible they should be drilled in place. After drilling the plates the burrs should be removed, the faying surfaces of the plates cleaned and the sharp outer edges of the holes removed.

From Board of Trade "Standard Conditions".

Where sizes of rivets are mentioned in the Standard Conditions the sizes refer to the diameters of the rivet holes, not to the diameters of the rivets used before closing.

From practice.

7. *End plates in steam space.*—The end plates in the steam space in way of uptakes are to be shielded from contact with the hot gases.

From Board of Trade "Standard Conditions".

8. *Hydraulic tests of New Boilers.*—In all new boilers working at pressures up to 100 lbs. per square inch the hydraulic test must be twice the working pressure. For boilers working at pressures greater than 100 lbs. per square inch the hydraulic test pressure must be 1½ times the working pressure *plus* 50 lbs. per square inch.

From Board of Trade "Standard Conditions".

SECTION II.—MATERIALS OF CONSTRUCTION.

Steel Plates, Rivets and Bars.

(Based on British Standards.)

Section II is taken from the Board of Trade "Standard Conditions" except clause 16.

1. *Process of Manufacture.*—Structural steel for boilers shall be made by the Open Hearth process, acid or basic.

2. *Freedom from Defects.*—The finished material shall be free from cracks, surface flaws, and lamination. It shall also have a workmanlike finish, and must not have been hammer dressed.

3. *Testing and Inspecting.*—The following tests and inspections shall be made at the place of manufacture prior to despatch; but, in the event of any of the material proving unsatisfactory in the course of being worked into boilers, such material shall be rejected, notwithstanding any previous certificate of satisfactory testing, and such further tests of the material from the same charge may be made as the Inspector in attendance may consider desirable.

4. *Tensile Test Pieces.*—The tensile strength and ductility shall be determined from Standard test pieces cut lengthwise or crosswise from the rolled material. When material is annealed or otherwise treated before despatch, the test pieces shall be similarly and simultaneously treated with the material before testing.

Plates.—Wherever practicable the rolled surfaces shall be retained on two opposite sides of the test piece. The elongation shall be measured on a Standard test piece having a gauge length of 8 inches.

For material more than $\frac{7}{8}$ inch in thickness the width of the test piece between the gauge points shall not exceed $1\frac{1}{2}$ inches; for material $\frac{7}{8}$ inch to $\frac{3}{8}$ inch in thickness, inclusive, the width shall not exceed 2 inches; for material less than $\frac{3}{8}$ inch in thickness the width shall not be more than $2\frac{1}{2}$ inches. In other respects the test pieces shall conform generally to the Standard Test Piece A of the British Engineering Standards Committee.

Round Bars.—Bars may be tested full size as rolled, or they may be turned down to a convenient size, and if tested 1 inch in diameter or under the test piece shall have a gauge length of 8 times the diameter. When enlarged ends are used the length of the parallel portion shall be 9 times the reduced diameter (Standard Test Piece B of the British Engineering Standards Committee). The sectional area of the test piece shall be not less than $\frac{1}{4}$ square inch. Where bars are above 1 inch in diameter, and are tested full size as rolled, or have been turned down and the resulting test piece is above 1 inch in diameter, a gauge length of 4 times the diameter may be used if preferred by the Manufacturer, in which case an increased elongation will be required, as specified in Clause 6. When enlarged ends are used the length of the parallel portion shall be not less than $4\frac{1}{2}$ times the reduced diameter (Standard Test Piece F of the British Engineering Standards Committee).

Any straightening of test pieces which may be required shall be done cold.

5. *Mechanical Tests, and Selection of Test Pieces.*—Plates and bars for boilers shall comply with the following mechanical tests. All test pieces shall be selected by the Inspector and tested in his presence, and he shall satisfy himself that the conditions herein described are fulfilled.

6. *Tensile Tests. Plates.*—The tensile breaking strength of steel plates for shells, gusset stays and girders, determined from Standard Test Pieces, shall be between the limits of 28 and 35 tons per square inch, but a range of not more than 4 tons per square inch shall be permitted in any one case. For plates intended for flanging or welding, and for combustion chambers and furnaces, the tensile breaking strength shall be between the limits of 26 tons and 30 tons per square inch. The elongation, measured on a standard test piece having a gauge length of 8 inches, shall be not less than 20 per cent. for material of $\frac{3}{4}$ inch in thickness and upwards required to have a tensile breaking strength between the limits of 28 tons and 35 tons per

square inch; and not less than 23 per cent. for material of ¾ inch in thickness and upwards required to have a tensile breaking strength between the limits of 26 tons and 30 tons per square inch.

Stay Bars.—The tensile breaking strength of longitudinal stays shall be between the limits of 28 tons and 35 tons per square inch, with an elongation of not less than 20 per cent. measured on the Standard Test Piece B, but a range of not more than 4 tons per square inch shall be permitted in any one case. For steel bars for combustion chamber stays the tensile breaking strength shall be between the limits of 26 tons and 30 tons per square inch, with an elongation of not less than 23 per cent. measured on the Standard Test Piece B.

Where Stay Bars are tested on a gauge length of 4 times the diameter (Test Piece F) the elongation shall be 24 per cent. and 28 per cent. respectively.

The tensile breaking strength of angle and tee bars shall be between the limits of 28 and 32 tons per square inch, with an elongation of not less than 20 per cent. measured on the Standard Test Piece A.

For material under ¾ inch in thickness the elongation may be 3 per cent., but not more than 3 per cent. below the above-named elongations.

Wherever practicable the rolled surfaces shall be retained on two opposite sides of the test piece.

Rivet Bars.—The tensile breaking strength of rivet bars shall be between the limits of 26 tons and 30 tons per square inch of section, with an elongation of not less than 25 per cent. measured on the Standard Test Piece B, or 30 per cent. measured on the Standard Test Piece F. The bars may be tested the full size as rolled.

7. *Number of Tensile Tests.—Plates.*—One tensile test shall be taken from each plate as rolled. For plates exceeding 2½ tons in weight one tensile test shall be taken from each end.

Angle, Tee, Rivet and Stay Bars.—One tensile test shall be made from each 15 or part of 15 bars rolled of each section or diameter from the same charge, but not less than two tensile tests shall be made unless the total number of bars rolled from the same charge is 8 or less than 8 and the bars are of the same section or diameter, in which case one tensile test will suffice. For round bars of 1¼ inches diameter and under, the numbers 50 and 20 shall be substituted for 15 and 8 respectively for determining the number of tests required.

Should a tensile test piece break outside the middle half of its gauge length, the test may, at the Maker's option, be discarded and another test be made of the same plate or bar.

8. *Bend Tests—Cold Bends.*—Test pieces shall be sheared lengthwise or crosswise from plates or bars, and shall not be less than 1½ inches wide but for small bars the whole section may be used. For rivet bars bend tests are not required.

Temper Bends.—The test pieces shall be similar to those used for cold bend tests. For temper bend tests the samples shall be heated to a blood-red colour and quenched in water at a temperature not exceeding 80 degrees Fahr. The colour shall be judged indoors in the shade.

In all cold bend tests, and in temper bend tests on samples 0·5 inch in thickness and above, the rough edge or arris caused by shearing may be removed by filing or grinding, and samples 1 inch in thickness and above may have the edges machined, but the test pieces shall receive no other preparation. The test pieces shall not be annealed unless the material from which they are cut is similarly annealed, in which case the test pieces shall be similarly and simultaneously treated with the material before testing.

For both cold and temper bends the test piece shall withstand, without fracture, being doubled over until the internal radius is equal to 1½ times the thickness of the test piece and the sides are parallel.

For small sectional material these bend tests may be made from the flattened bar.

Bend tests may be made either by pressure or by blows.

9. *Number of Bend Tests. Plates.*—A cold or a temper bend test shall be taken from each plate as rolled. For plates exceeding 2½ tons in weight one bend test shall be taken from each end.

The bend tests from shell plates, butt straps and other plates which have not to be flanged or worked in the fire or which when in use are not to be exposed to flame are to be cold bend tests. The bend tests from plates which have to be flanged or worked in the fire or which when in use will be exposed to flame are to be temper bend tests. In the case of shell plates permitted to have a tensile breaking strength above 34 tons per square inch, one temper bend test must be made in addition to the cold bends above specified in the case of each plate which is above 34 tons per square inch.

Angle Bars.—A cold or a temper bend test shall be made from each angle bar rolled.

Stay Bars.—A cold and a temper bend test shall be made from every 15 stay bars as rolled from each charge.

10. *Tests for Manufactured Rivets.*—Rivets selected by the Inspector from the bulk shall withstand the following tests :—

(*a*) The rivet shanks are to be bent cold, and hammered until two parts of the shank touch, without fracture on the outside of the bend.

(*b*) The rivet heads are to be flattened, while hot, in the usual manner, without cracking at the edges. The heads are to be flattened until their diameter is 2½ times the diameter of the shank.

11. *Additional Tests before Rejection.*—Should the test pieces first selected by the Inspector not fulfil the test requirements, two further tests of the same kind may be made, but should either of these fail, the plates or bars from which test pieces were cut shall be rejected. In all such cases further tests shall be made before any material from the same charge can be accepted.

12. *Branding.*—Every plate and bar shall be clearly and distinctly marked by the maker in two places with an approved quality brand indicating that the material has complied with the required tests ; and also with the number or identification marks by which they can be traced to the charge from which the material was made.

13. *Defacing of Rejected Material.*—In the event of the material failing in any case to withstand the prescribed tests, the Inspector shall see that the quality brand stamped on the material has been defaced by punch marks extending beyond the brand in the form of a cross, denoting that the material has been rejected.

14. *Facilities for Inspection.*—The maker shall adopt a system of marking the ingots, billets, slabs, plates, bars, etc., which will enable all finished material to be traced to the original charge, and the Inspector must be given every facility for tracing all plates and bars to their respective charges, and for witnessing the required tests. When he is satisfied with the material and with the results of the tests, he shall be furnished with two copies of the advice notes of the material for his signature.

15. *Steel not produced where rolled.*—Where steel is not produced in the works at which it is rolled, a certificate shall be supplied to the Inspector deputed to witness the testing of the material, stating the Open Hearth Process by which it was made, the name of the Steel Maker who supplied it, also the numbers of the charges for reference to the books of the Steel Maker. The number of the charge shall be marked on each plate or bar for the purpose of identification.

16. *Maker's certificate.*—Before the mill sheets are signed, the Maker shall furnish the Inspector with a certificate guaranteeing that the material has been made by the Open Hearth Process acid or basic, and that it has been subjected to, and has withstood satisfactorily, the tests above described in the presence of the Inspector. The following form of

This is taken from the British Engineering Standards Specification with the addition of the words " acid or basic ".

certificate will be accepted if printed on each mill sheet with the name of the firm, and initialled by the Test House Manager :—

"We hereby certify that the material described below has been made by the Open Hearth Process, $\frac{\text{(acid)}}{\text{(basic)}}$, and has been satisfactorily tested in the presence of $\frac{\text{your Inspector}}{\text{our Test House Manager}}$ in accordance with the Standard tests."

Iron Plates, Rivets and Bars.

17. *Tests.*—If full allowance for iron shell plates, stay bars and rivets is required, the material must be tested in the same way as steel in accordance with the following requirements.

From general practice.

From Bombay Revised Rules based on Board of Trade and other British Engineering Authorities.

18. *Plates.*—The tensile breaking strength shall not be less than 22 tons per square inch with the grain and 20 tons per square inch across the grain. The elongation shall not be less than 16 per cent. with, and 10 per cent. across the grain.

From Bombay Revised Rules based on Board of Trade and other British Engineering Authorities.

19. *Rivet Bars.*—The tensile breaking strength shall not be less than 25 tons per square inch, with an elongation of not less than 27 per cent. measured on the Standard Test Piece B. or 32 per cent. measured on the Standard Test Piece F. The bars may be tested the full size as rolled.

From Board of Trade "Standard Conditions" for Steel Rivets.

20. *Tests for manufactured rivets.*—To be the same as for steel. (See Clause 10.)

From Traills "Boilers, Marine and Land" other authorities and general practice.

21. *Stay Bars.*—The tensile breaking strength shall not be less than 21 tons per square inch, with an elongation of not less than 20 per cent. measured on the Standard Test Piece B. or 25 per cent. measured on the Standard Test Piece F.

From Board of Trade Standard Conditions".

Special Iron for Screw Stays, for Fireboxes and Combustion Chambers.—In order that iron screw stays may be approved of the same size as would be required for mild steel the iron must withstand the following tests :—

22. *Tensile Tests.*—The tensile breaking strength shall not be less than 21½ tons per square inch, with an elongation of not less than 25 per cent. measured on the Standard Test Piece B or 30 per cent. measured on the Standard Test Piece F.

23. *Bend Tests.*—Test pieces either of the bar as rolled, or turned down to 1 inch diameter, shall stand bending cold until the sides are parallel and the space between the two sides is not greater than the diameter of the test piece.

24. *Number of tensile tests.*—The bars as rolled are to be placed in batches of twenty, and one tensile test is to be taken from each batch. If this is unsatisfactory, two other bars are to be selected for test, but should either of these fail the batch is to be rejected.

25. *Number of bend tests.*—One ordinary bend test is to be taken from each batch, and a similar test piece from each batch is to be lightly and evenly nicked on one side with a sharp cutting tool and bent back at this point through an angle of 180 degrees by pressure or by a succession of light blows. The fracture must be clean, fibrous, free from slag or dirt or any coarse crystalline structure. If either of these is unsatisfactory, two other bars are to be selected for test, but should either of these fail the batch is to be rejected.

In all cases the selection of the test pieces is to be made by the Inspectors.

Copper Plates, Stay and Rivet Bars.

26. *Tensile Tests. Plates.*—The tensile breaking strength of copper plates for fireboxes determined from Standard test pieces shall not be less than 14 tons per square inch with an elongation of not less than 35 per cent.

From Unwin's "Machine Design" and Hiller's "Steam Boiler Construction".

Stay and Rivet Bars.—The tensile breaking strength of copper stay and rivet bars for fireboxes shall not be less than 14 tons per square inch of section with an elongation of not less than 40 per cent. measured on the Standard Test Piece B.

27. *Bend Tests. Plates.*—For either cold or red hot tests the test piece shall withstand being doubled over without fracture until the sides are touching and parallel.

From Hiller's "Steam Boiler Construction," *i.e.* the Rules of the National Boiler Insurance Company.

28. *Hammer Tests for Rods.*—A piece of rod or bar 1 inch in length shall withstand, without cracking at the edges, being hammered endwise until the length is reduced to $\frac{5}{8}$ inch.

Cast Steel.

29. *Steel Castings.*—Steel for castings shall be made by the Open Hearth Process, acid or basic, and all such castings shall be thoroughly annealed at a uniform temperature and be allowed to cool down prior to removal from the annealing furnace. If subsequently heated with the Inspector's approval, they shall again be similarly annealed if required by the Inspector.

From Board of Trade and British Standard Specifications.

30. *Tensile and Bend Tests.*—If full allowance for steel castings for firebox or combustion chamber roof girders is required, they shall be tested as follows :—

31. *Number of Tests.*—At least one tensile and one bend test shall be made from the casting from each charge, and when more than one casting is made from one charge, at least one tensile and one bend test shall be made from the castings run from one common pouring head ; but separate tests should be made from each casting or set of castings run from each separate pouring head.

Test pieces shall not be cut off until they have been stamped by the Inspector after the annealing has been completed.

32. *Tensile Tests.*—The tensile breaking strength of steel castings shall be between the limits of 26 and 40 tons per square inch, with an elongation of not less than 15 per cent. measured on the Standard Test Piece C, D or E (See Forms of British Standard Tensile Test Pieces).

33. *Bend Tests.*—Cold bend tests shall be made upon test pieces having a rectangular section of 1 inch wide by $\frac{3}{4}$ inch thick. The test pieces shall be machined and the edges rounded to a radius of $\frac{1}{16}$th inch. The test pieces shall be bent over the thinner section.

From Board of Trade and British Standard Specifications

Bend tests may be made by pressure or by blows.

The test pieces must withstand, without fracture, being bent through an angle of 60 degrees if the tensile breaking strength is between 35 and 40 tons per square inch, and, in the case of other castings through an angle of 90 degrees, but if they are required to be of superior quality the angle should not be less than 120 degrees, the internal radius of the bend being not greater than 1 inch.

34. If full allowance for steel castings is not required only bend tests as above need be taken.

From Board of Trade Regulations and Bombay Revised Rules.

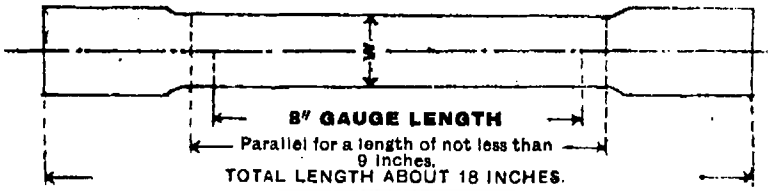
No tests need be made from unimportant steel castings or from steel castings which are used for articles usually made of cast iron if the scantlings are not materially reduced below what would be required if cast iron were used.

FORMS OF BRITISH STANDARD TENSILE TEST PIECES.

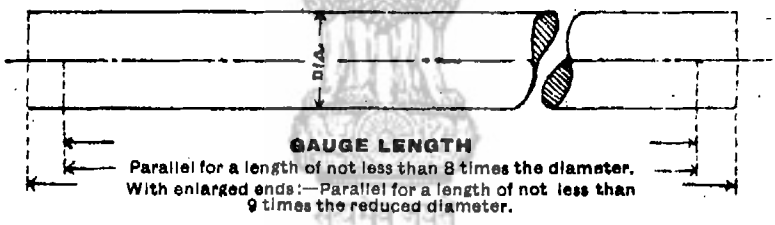
For plates and other structural material.

TEST PIECE A.

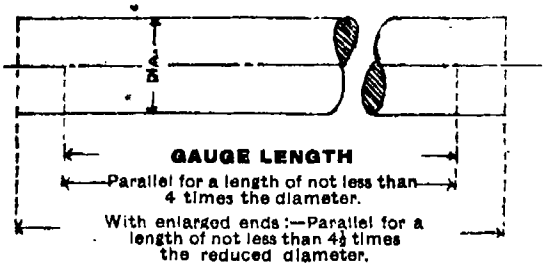
For thicknesses over $\frac{7}{8}$" :—Maximum width allowed = $1\frac{1}{2}$ inches.
For thicknesses $\frac{3}{8}$" to $\frac{7}{8}$" :—Maximum width allowed = 2 inches.
For thicknesses under $\frac{3}{8}$" :—Maximum width allowed = $2\frac{1}{2}$ inches.



TEST PIECE B.



TEST PIECE F.



SECTION III.—RULES FOR DETERMINING THE WORKING PRESSURE TO BE ALLOWED ON VARIOUS PARTS OF BOILERS.

Cylindrical Shells.

1. *Formula for Working Pressure of Shell.*—"For cylindrical shells, barrels, steam and water drums, and domes of boilers the maximum working pressure per square inch to be allowed shall be calculated from the following formula":—

Adapted from Board of Trade "Standard Condition" to suit various types of land boilers.

Equation 1.

$$\text{W. P.} = \frac{(t-2) \times S \times J.}{C \times D.} \quad . \quad . \quad .$$

W. P. is the working pressure in lbs. per square inch.

t is the thickness of shell plates in 32nds of an inch.

S. is the minimum tensile breaking strength of the shell plates in tons per square inch, "or whatever strength is allowed under Clause 2 of this section."

Last sub-paragraph added to provide for material not up to standard.

J. is the percentage of strength of the longitudinal seams of shell "or of a line of holes in the shell for tubes, stays, or rivets, or of an opening in the shell not fully compensated, whichever is least" calculated by the methods hereafter described;

Alternatives added to suit various types and conditions.

C. is a co-efficient as follows:—

2·75 when the longitudinal seams are made with double butt straps "and when small shells are formed from solid rolled sections."

Added to provide for certain small shells.

2·83 when the longitudinal seams are made with lap joints and are treble riveted.

2·9 when the longitudinal seams are made with lap joints and are double riveted.

"3·0 when the longitudinal seams are welded and are fitted with a single butt strap."

Added to provide for the stated condition.

3·3 when the longitudinal seams are made with lap joints and are single riveted.

D. is the inside diameter of the outer strake of plating of the cylindrical shell measured in inches.

The Factor of Safety must be in no case less than 4.

"An addition of 10 per cent. shall be made to the appropriate co-efficient for shell plates of externally fired boilers exposed to the direct impact of furnace flame and for shell plates into which tubes are expanded."

New, from Bombay Revised Rules.

The above co-efficients are standard and are to be used only for boilers open to inspection by an Inspector during the whole period of construction and which are certified by him as having been constructed in accordance with the Standard Conditions laid down in these rules.

New—explanatory.

New, to provide for boilers not up to standard but fit for work at a reduced pressure. From Bombay Revised Rules and practice.

2. *Boiler shells not in accordance with Standard Conditions.*—When the standard conditions are not complied with, additions to the appropriate co-efficient are to be made as follows:—

For shells with best type of joint and up to standard. The factor of safety is 4. If (*a*) and (*b*) be added, and 24 tons instead of 28 tons be allowed the equivalent factor of safety will be 5·8, which is not too high for unknown conditions.

(*a*) 15 per cent. of the standard co-efficient when there are no proofs of tests of material. In such cases if the Inspector is satisfied that the shell plates are of good material, S in Equation I shall be taken at 24 tons for steel, 21 tons for iron with the grain and 18 tons for iron across the grain.

(*b*) 10 per cent. of the standard co-efficient when a boiler has not been inspected during construction by an Inspector and certified by him.

(*c*) 1 per cent. of the standard co-efficient for each ton or part of a ton by which the minimum tensile breaking strength of steel shell plates is below the minimum prescribed in Section II.

Steel having a tensile breaking strength below 24 tons should be treated as iron.

(*d*) Such percentage of the standard co-efficient when the workmanship is in any way doubtful and the Inspector is not satisfied that any of the foregoing additions to the co-efficient would be sufficient to meet the circumstances as the Chief Inspector deems fit.

Addition not specified, to be left to discretion of Chief Inspector—old practice.

3. "*Minimum Thickness of Shell Plates.*—Shell plates must not be less than $\frac{1}{4}$ inch in thickness."

From Bombay Revised Rules and experience.

4. "*Position of Longitudinal Seams.*—Each ring of plate forming the shell, barrel or drum should be in one piece and have its longitudinal seam well out of line with those of the adjoining rings. In Lancashire, Cornish, and Water tube boilers, where parts of the shell are exposed to flame the longitudinal seams should be in the steam space, arranged alternately on each side of the crown and clear of the brick work."

From Bombay Revised Rules and experience.

5. "*Riveting of End Seams.*—The riveting of the seams joining the end plates to the cylindrical shell should be not less than 42 per cent. of that of the solid plate. Where the shell plates exceed $\frac{5}{8}$ inch in thickness the seams connecting the shell plates to the end plates or angle bar are to be double riveted."

From Board of Trade "Standard Conditions".

6. "*Other Circumferential Seams.*—The circumferential seams joining the rings of shell plates should have a strength of joint not less than 50 per cent. of the solid plate. Where the shell plates exceed $\frac{1}{4}$ inch in thickness, the intermediate circumferential seams of Lancashire, Cornish, and Marine type Boilers are to be at least double riveted."

Adapted from Board of Trade "Standard Conditions". Inapplicable portions of original omitted and minimum percentage of joint reduced from 62 to 50. As at present constructed the circumferential seams of Lancashire and Cornish boilers very seldom have a strength percentage of 62.

7. *Welded Shell Plates.*—"Welded seams in boiler shells must not be passed unless" the weld is covered by a butt strap or straps "securely riveted to the shell." For small steam domes where the welding is done by hammer and the plates do not exceed ½ inch in thickness the straps may be omitted. The strength shall in such cases be assumed to be 50 per cent. of that of the solid plate. "The thickness of the covering strap over the weld should be in accordance with the rules for butt straps."

Adapted from Board of Trade Standard Conditions.

8. *Butt Ends of Shell Rings.*—The ends of shell plate rings where butted should be given the same curvature in the rolls as the rest of the ring. The setting should not be done by hammering.

From Bombay Revised Rules.

9. "*Butt Straps.*—Butt straps must be cut from plates and not from rolled strip." "They should be bent in the rolls to the required curve. Thinning of the ends of butt straps which tuck under the shell rings should be done by machine and not by heating and hammering."

From Board of Trade "Standard Conditions."

From Bombay Revised Rules.

10. *Methods of Calculating the Strength of Riveted Joints.*—The percentage of strength of a riveted joint (J) is found from the following formulæ (*a*), (*b*), (*c*): (*a*) and (*b*) are applicable to any ordinary type of joint; (*c*) is applicable only to that type of joint in which the number of rivets in the inner rows is double that of the outer row. The lowest value given by the application of these formulæ is to be taken as the percentage of strength of the joint compared with the solid plate.

From Board of Trade "Standard Conditions."

Equation 2.

$$(a)\ \frac{100\ (P-D)}{P.} = \text{Plate percentage.}$$

Equation 3.

$$(b)\ \frac{100 \times A \times N \times C \times S_1}{P \times T \times S} = \text{Rivet percentage.}$$

Equation 4.

$$(c)\ \frac{100\ (P-2\ D)}{P} + \frac{100 \times A \times C \times S_1}{P \times T \times S} = \text{Combined Plate and rivet percentage.}$$

P is the pitch of rivets at outer row in inches,

D is the diameter of rivet holes in inches,

A is the sectional area of one rivet hole in square inches,

N is the number of rivets per pitch, (P).

T is the thickness of plate in inches,

C is a constant which =1 for rivets in single shear as in lap joints, and 1·875 for rivets in double shear as in double butt strapped joints.

S_1 is the shearing strength of rivets, which is taken generally to be 23 tons per square inch for steel "and 18 tons per square inch for iron," and may, "in each case," be 85 per cent. of the minimum tensile breaking strength of the rivet bars.

Provision made for iron rivets.

S is the minimum tensile breaking strength of shell plates in tons per square inch "or whatever strength is allowed under clause 2 of this section."

Last sub-paragraph added to provide for material not up to standard.

In the first formula (a) D is the diameter of the rivet holes in the outer rows and in the third formula D is the diameter of the rivet holes in the next rows. In the last formula A is the area of one rivet hole in the outer row.

New—explanatory.

When the sectional area of the rivet holes is not the same in all rows, and when some of the rivets are in double shear and others in single shear, the rivet sections per pitch of each size or shear should be computed separately and added together to form the total rivet section.

11. *When pitch exceeds maximum allowed.*—Should the pitch of the rivets exceed the maximum pitch allowed, the permissible pitch is to be used in place of the actual pitch in determining the percentage of plate section, "but in no circumstances shall a greater percentage than 85 be allowed for any type of joint."

Taken from Bombay Revised Rules and practice. Necessary to penalise bad design.

Percentage of strength of any joint limited to 85 is a new provision to prevent unduly high allowance for freak joints

12. *Butt straps and spacing of rivets below requirements.*—Should the spacing of the rows of rivets or the distance between edge of plate and rivet hole, or the thickness of butt straps be less than is specified in the following rules, the percentage representing the strength of joint should be modified as prescribed in those rules.

Taken from Bombay Revised Rules and practice. Necessary to penalise bad design.

13. *Percentage of welded and strapped seams.*—In determining the percentage of strength of a welded seam covered by a strap or straps the above formulæ are applicable, but 50 per cent. should be added to the rivet percentage for the weld.

New—from practice.

14. *Percentage to be allowed for solid rolled shells.*—When small shells are rolled from the solid, J in Equation I may be taken as 95 per cent.

From Bombay Revised Rules—slightly modified.

15. *Thickness of butt straps.*—The minimum thickness of butt straps for the longitudinal seams of cylindrical shells should be determined by the following formulæ, but all straps should be of sufficient thickness to permit of efficient caulking.

From Bombay Revised Rules and Board of Trade "Standard Conditions."

Single butt straps having ordinary riveting—

Equation 5.

$$1{\cdot}125\ T = T_1.$$

Single Butt Straps having every alternate Rivet in the outer rows omitted.—

Equation 6.

$$1{\cdot}125\ T \times \frac{(P-D)}{(P-2D)} = T_1.$$

Double butt straps of equal width having ordinary riveting.—

Equation 7.

$$\cdot 625\ T = T_1.$$

Double butt straps of equal width having every alternate rivet in the outer rows omitted.—

Equation 8.

$$\cdot 625 \times \frac{(P-D)}{(P-2D)} = T_1.$$

Double butt straps of unequal width having ordinary riveting.—

Equation 9.

$$\cdot 75\ T = T_1 \text{ (wide strap).}$$

Equation 10.

$$\cdot 625\ T = T_1 \text{ (narrow strap).}$$

Double butt straps of unequal width having every alternate rivet in the outer rows omitted.—

Equation 11.

$$\cdot 75\ T \times \frac{(P-D)}{(P-2\ D)} = T_1 \text{ (wide strap).}$$

Equation 12.

$$\cdot 625\ T \times \frac{(P-D)}{(P-2\ D)} = T_1 \text{ (narrow strap).}$$

T_1 is the thickness of the butt straps in inches. The other symbols have the same significance as in clause 10 of this section.

" Single and wide butt straps must always be on the inside of the shell."

New—from practice.

" Should the thickness of butt straps be less than that above described the least percentage of joint as determined under clause 10 should be reduced in the proportion of the actual thickness to the prescribed thickness."

New—provision for straps not up to standard.

16. *Maximum pitch of rivets in longitudinal joints.*—The maximum pitch of the rivets in the longitudinal joints of boiler shells is to be :—

From Board of Trade "Standard Conditions" with a column for single butt strapped joints added.

Equation 13.

$C \times T + 1{\cdot}625$ maximum pitch in inches.

T is the thickness of the shell plate in inches,

C is a co-efficient as given in the following table :—

Number of Rivets per Pitch.	Co-efficients for Lap Joints.	Co-efficients for single Butt-strapped joints.	Co-efficients for double Butt-strapped joints.
1	1·31	1·53	1·75
2	2·62	3·06	3·50
3	3·47	4·05	4·63
4	4·14	...	5·52
5	...	...	6·00

Distances between rows of rivets and between rivets and plate edges.—In all cases the clear space between a rivet hole and the edge of a plate should not be less than the diameter of the rivet holes, *i.e.*, the centre of the rivet hole should be at least $1\frac{1}{2}$" diameters distant from the edge of the plate.

From Board of Trade "Standard Conditions".

In joints, whether lapped or fitted with butt straps, in which there are more than one row of rivets and in which there is an equal number of rivets in each row, the distance between the rows of rivets should be not less than—

From Board of Trade "Standard Conditions."

Zig-zag Riveting,

Equation 14.

$$\cdot 33\ P + \cdot 67\ D = \text{distance between rows,}$$

Chain Riveting.

Equation 15.

$$2\ D = \text{distance between rows.}$$

In joints in which the number of rivets in the outer rows is one half of the number in each of the inner rows, and in which the inner rows are chain riveted, the distance between the outer rows and the next rows should be not less than—

Equation 16.

$$\cdot 33\ P + \cdot 67\ D \text{ or } 2\ D = \text{distance between rows.}$$

whichever is the greater, and the distance between the rows in which there are the full number of rivets should be not less than 2 D.

In joints in which the number of rivets in the outer rows is one half of the number in each of the inner rows, and in which the inner rows are zig-zag, the distance between the outer rows and the next rows should be not less than—

Equation 17.

$$\cdot 2\ P + 1 \cdot 15\ D = \text{distance between outer and next rows.}$$

The distance between the rows in which there are the full number of rivets should be not less than—

Equation 18.

$$\cdot 165\ P + \cdot 67\ D = \text{distance between inner rows,}$$

P is the pitch of the rivets in the outer rows,

"D is the diameter of the rivet holes in inches or the mean diameters of rivet holes when the distance to be determined is between two rows of rivets of different diameters."

New—explanatory.

Should the distance between rows of rivets be less than as prescribed above, the plate percentage determined by Equation 2 should be modified thus—

New—Provision for spacing not up to the Standard.

Equation 19.

$$\frac{100\left[P - \left(2 - \frac{\text{actual distance}}{\text{prescribed distance}}\right)D\right]}{P} = \text{distance of rows percentage,}$$

18. *Complete Hemisphere without stays or other support made of more than one plate and subject to internal pressure.*

Taken from Board of Trade "Standard Conditions."

Equation 20.

$$W.P. = \frac{(t-2) \times S \times J}{C \times R}$$

W. P. is the working pressure in lbs. per spuare inch,

t is the thickness of the end plates in 32nds of an inch,

S is the minimum tensile breaking strength of the end plates in tons per square inch, "or whatever strength is allowed for them,"

J is the strength of riveted joint per cent. of solid plate,

R is the inner radius of curvature in inches,

C for single riveting is 3·3,

C for double riveting is 2·9,

C for treble riveting is 2·83.

19. *Dished or hemispherical ends formed in one piece and subject to internal pressure.*—For ends of steam and water drums, tops of vertical boilers, etc., when either dished to partial spherical form or when hemispherical in form, and without stays, the following formula is to be used :—

Taken from Board of Trade "Standard Conditions."—Description enlarged.

Equation 21.

$$W.P. = \frac{15 \times S\ (t-1)}{R}$$

W. P. is the working pressure in lbs. per spuare inch,

t is the thickness of end plates in 32nds of an inch,

R is the inner radius of curvature of the end in inches, which shall not exceed the diameter of the shell to which it is attached,

S is the minimum tensile breaking strength of plate in tons per square inch, "or whatever is allowed for it."

When the end has a manhole in it, $\frac{4}{32}$nds must be added to the thickness of the plate. The inside radius of curvature at the flange must not be less than 4 times the thickness of the end plate, and in no case less than $2\frac{1}{2}$ inches.

The total depth of flange of manhole from the outer surface in inches is to be at least equal to.

Equation 22.

$$\sqrt{T \times W}$$

where T is the thickness of the plate in inches, and W. is the minor axis in inches.

20. *Similar ends to the above but subject to external pressure.*—For similar ends subject to external pressure (in compression) the co-efficient 15 in Equation 21 should be substituted by 12, and R should be the outer radius of curvature of plate. For plates exposed to furnace flame the co-efficient should be 10·5.

New—adapted from Board of Trade "Standard Conditions." Allows about 4750 lbs. stress per inch of section when S=26 tons.

21. *Dished ends of Lancashire and Cornish type boilers.*—For dished ends of Lancashire and Cornish boilers with external or internal flanges for furnaces formed in one piece, without stays and subject to internal pressure, the following formula is to be used :—

Adapted from Board of Trade "Standard Conditions" formula.

Allows about 9,000 lbs. stress per inch of section when S=26 tons, which agrees with good practice.

Equation 23.

$$W.P. = \frac{22 \times S\ (t-1)}{R.}$$

W. P. is the working pressure in lbs. per square inch,

t is the thickness of the end plate in 32nds of an inch,

R is the inner radius of curvature of the end in inches which shall not exceed one and a half times the internal diameter of the shell to which it is attached,

S is the minimum tensile breaking strength of the plate in tons per square inch "or whatever is allowed for it."

The inside radius of curvature at the flange must not be less than 4 times the thickness of the plate and in no case less than 3½ inches. When the end plate has a manhole in it the total depth of the flange from the outer surface in inches is to be at least equal to—

Equation 24.

$$\sqrt{\frac{}{T \times W}}$$

where T is the thickness of the plate in inches and W is the minor axis in inches.

Dished plates should be pressed to shape and flanged at one operation and efficiently annealed afterwards.

22. *Dished ends with Uptakes.*—No account should be taken of the influence of the uptake tube in vertical boilers when determining the pressure by the above rules. If dished crown plates having uptakes are fit for higher pressures, when considered as flat plates, such higher pressure should be allowed.

From Bombay Revised Rules.

The radius R of the dished part may be found as follows :—

Equation 25.

$$R = \frac{C^2 + H^2}{2H.}$$

C and H are the lengths in inches of half the base line or chord on which H is measured and the height of the dish or camber at the middle of the chord respectively.

Flat Plates.

23. *Flat plates supported by screwed stays.*—The working pressure to be allowed on flat plates supported by stays is to be calculated by the following formula :—

From Board of Trade "Standard conditions."

Equation 26.

$$W.P. = \frac{(t-1)^2 \times C}{A^2 + B^2}$$

n this formula and in those following in this sub-section,

W. P. is the working pressure in lbs. per square inch,

t is the thickness of the flat plate in 32nds of an inch,

t_1 is the thickness of the washers, strips, or doublings employed, in 32nds of an inch,

A is the distance apart of the rows of stays, in inches,

B is the pitch of the stays, in the rows, in inches,

C is a co-efficient which varies with the method of fixing the stays as follows :—

Where the plates are exposed to flame and the stays are screwed into the plate and their ends are riveted over, C=50.

Where the plates are not exposed to flame and the stays are screwed into the plate and their ends are riveted over, C=57.

In these cases the thickness of the plate must be at least half the diameter of the stay required by the rule.

Where stay tubes are screwed into tube plates and expanded, C=52. If they are fitted with nuts, C=72.

Where the plates are exposed to flame and the stays are screwed into the plate and fitted with nuts on the outside, C=75, where the plates are not exposed to flame, C=86.

Where the stays pass through plates not exposed to flame and are fitted with nuts inside and outside, C=96.

Where plates are stiffened by flanging, the inner radius of which is not greater than 2½ times the thickness of the plate, for the support thus given, C=110 where the plates are not exposed to flame, and C=96 where they are exposed to flame. The pitch is to be reckoned from the commencement of the curvature.

For portions of plate where the stays are irregularly pitched D^2 is to be used instead of A^2+B^2, D being the diameter of the largest circle which can be drawn passing through not less than three points of support *viz.*, the centres of stays, or rivets, or the commencement of the curvature of flanging, whichever is applicable. In this case C is to be taken as the mean of the values appropriate for the points of support.

For the tops and sides of combustion chambers and fire boxes the distance between the rows of stays nearest to the back tube plate, or the back or firehole plate respectively, and the commencement of curvature of these plates at their flanges, shall not be greater than A.

For the tops of combustion chambers and fireboxes where they are joined to the sides by curved portions, if the outer radius of the curved portion is less than half the allowable distance between the girders, the distance between the first girder and the inner surface of the side plates should not exceed the allowable distance between the girders. If the radius of curvature is greater than half the allowable distance between the girders, the width of the flat portion measured from the centre of the girder should not be more than half the allowable distance between the girders.

Where portions of plates are supported by stays secured in different ways, the value of C to be taken is the mean of the values appropriate to the method of securing the supporting stays.

From Board of Trade "Standard Conditions."

24. *Flat plates supported by stays and nuts and large washers or strips or doublings.*—Where the plates are supported by stays passing through them and are fitted with nuts inside and washers and nuts outside, the diameter of the washers being at least 3½ times that of the stay, and their thickness at least two thirds that of the plate, but not greater than that of the plate, the working pressure shall be :—

Equation 27.

$$W.P. = \frac{100}{A^2+B^2} \cdot [(t-1)^2 + \cdot 15\ t_1^2].$$

Where the washers have a diameter of at least two thirds of the pitch of the stays and a thickness of at least two thirds of the thickness of the plate, but not greater than that of the plate, and are riveted to the plate in an efficient manner the working pressure shall be :—

Equation 28.

$$W.P. = \frac{100}{A^2+B^2}\left[(t-1)^2 + \cdot 35\ t_1^2\right].$$

Where the plate is stiffened by strips at least two thirds of the pitch of the stays in breadth which have a thickness of at least two thirds of that of the plate, but not greater than that of the plate, and are riveted to the plate in an efficient manner, the working pressure shall be :—

Equation 29.

$$W.P. = \frac{100}{A^2+B^2}\left[(t-1)^2 + \cdot 55\ t_1^2\right].$$

Where the plates are fitted with doubling plates having a thickness of at least two thirds of that of the plate, but not greater than that of the plate, and are riveted to them in an efficient manner the working pressure shall be :—

Equation 30.

$$W.P. = \frac{100}{A^2+B^2}\left[(t-1)^2 + \cdot 85\ t_1^2\right].$$

25. *Back and front tube plates.*—No nuts are to be fitted to stay tubes at the combustion chamber or fire-box end.

For the portions of tube plates in the nests of tubes,—

Equation 31.

$$W.P. = \frac{C\,(t-1)^2}{P^2}$$

P is the mean pitch of the stay tubes supporting any portion of the plate (being the sum of the four sides of the quadrilateral divided by four)

C=38 when the stay tubes are screwed and expanded into the plate and no nuts are fitted.

C=49 when the stay tubes are screwed and expanded into the plate and fitted with nuts.

For the wide water spaces of front tube plates between the nests of tubes, and between the wing rows of tubes and the shell,—

Equation 32.

$$W.P. = \frac{C\left[(t-1)^2 + \cdot 55\ t_1^2\right]}{A^2+B^2}$$

A is the horizontal pitch of stay tubes in inches measured across the wide water space from centre to centre ;

B is the vertical pitch of stay tubes in the bounding rows in inches measured from centre to centre ;

C = 52 when the stay tubes are screwed and expanded into the tube plates and no nuts are fitted ;

C = 72 when the stay tubes are screwed and expanded into the tube plates and nuts are fitted to each stay tube ;

C = 63 when the stay tubes are screwed and expanded into the tube plates and nuts are fitted only to alternate stay tubes.

New—adapted from Board of Trade "Standard Conditions." Co-efficient determined by comparison with Bombay Rules and the National Boiler Insurance Company's Rules and from practice.

26. *Plates supported by gusset stays.*—For the end plates of Lancashire, Cornish, Vertical and Locotype boilers, and other flat surfaces supported by irregular pitched gusset stays the working pressure is to be determined as follows :—

Equation 33.

$$\text{W. P.} = \frac{C\,(t-1)^2}{D^2}$$

D is the diameter of the largest circle which can be drawn passing through not less than three points of support *viz.*, the centre lines of rivets or the commencement of the curvature of flanging, whichever is applicable.

C=100 for plates not exposed to flame ;

C=88 for plates exposed to flame.

Where such plates are stiffened by suitable tee or angle bars securely riveted to the plates within the circle D, the appropriate co-efficient may be increased thirty per cent. Such stiffening bars should be placed so as to transmit their load in a direct manner to the gusset stays or shell plate.

From Bombay Revised Rules and practice.

New—adapted from Board of Trade "Standard Conditions" and Bombay Revised Rules and practice.

For the part of the end plate containing the manhole in Lancashire boilers the following formula is to be used :—

Equation 34.

$$\text{W. P.} = \frac{C\,[(t-1)^2+(t_1-1)^2]}{D^2}$$

where D is the diameter of the largest circle which can be drawn enclosing the manhole and passing through the centres of the rivets in end plates connecting the shell and gusset angles and furnaces, or to the commencement of curvature of flanging whichever is applicable ;

t is the thickness of the end plate in 32nds of an inch ;

t_1 is the thickness of the base of the mouthpiece or flat ring in 32nds of an inch ;

C=90 when the manhole mouthpiece is either of mild or cast steel, and has a turned-in flange of a depth, measured from inside of end plate, of not less than 4 times the thickness of the end plate, and a thickness not less than the thickness of the end plate.

C=70 when only a flat steel compensating ring is fitted.

27. *Flanged manholes and mudholes in flat plates.*—When a flat plate is flanged to stiffen it at a manhole or sight hole, to permit the same working pressure as would be allowed upon an unpierced plate, the depth of the flange measured from the outer surface is to be at least equal to—

From Board of Trade "Standard conditions."

Equation 35.

$$\sqrt{T \times W}$$

where T is the thickness of the plate in inches, and W is the minor axis of the hole in inches.

28. *Flat crown plates of vertical boilers.*—For the flat crown plates or vertical boilers either with or without bolt stays, use equation 33 in determining the working pressure with C=80 when the plates are not exposed to flame and 70 when they are exposed to flame. In this case the circle D is the largest that can be drawn passing through the centres of the rivets or bolt stays when fitted, or to the commencement of the curvature of the flanging, whichever is applicable. Where bolt stays are fitted with washers of the same thickness as the plate securely riveted thereto, the circle should pass through the centres of the washer rivets, but where the washers are not riveted or where none are fitted the circle should pass through the centres of the stays.

New—adapted from Board of Trade "Standard Conditions" and National Boiler Insurance Company's Rules.

29. *Circular flat ends.*—For circular flat ends supported only at edges, C is to be taken as 120 when the plates are not exposed to flame and 105 when they are exposed to flame. In this case the circle D should pass through the centre line of rivets or bolts securing the end to the shell or, when the end is flanged, through the commencement of curvature.

Adapted from Board of Trade "Standard Conditions" and practice.

30. *Bar or bulb stiffened end plates and smokebox tube plates of locotype boilers.*—Where such plates instead of being supported by stays are stiffened in the steam space by substantial tee or angle bars securely riveted to the plate and extending across the plate to within the margin allowed by the following rule, or where such plates are formed with a deep bulb extending across the plate to within the margin allowed, for the support thus given

Adapted from Board of Trade "Standard Conditions" and practice.

C may be taken as = 80 and 70 for plates not exposed and exposed to flame respectively. The margin or pitch for such stiffening should be measured from the centre line of rivets or commencement of curvature of bulb providing it is not more than 2 inches from the centre line of bulb.

For the flat plate above the stiffener or bulb, C is to be taken as the mean of the values appropriate for the points of support.

31. *Flat plate margins.*—The amount of support in relief of stays which may be credited to the sides of shells, furnaces, uptakes, firehole and foundation rings, etc., to which flat plates are attached should not exceed that found by the following formula—

Adapted from Board of Trade "Standard Conditions" and practice.

Equation 36.

$$\frac{1}{2} \times \sqrt{\frac{C(t-1)^2}{W.P.}}.$$

W. P. is the intended working pressure in lbs. per square inch.

C=90 where the plates are not exposed to flame,

C=80 where the plates are exposed to flame.

Where the plates are flanged the margin should be measured from the side of the flange next the inner radius of corner. In other cases the margin is to be measured from the centres of riveted seams.

Stays.

32. *Iron or steel screw stays to combustion chambers and fireboxes.*—For screw stays with threads not coarser than 9 threads per inch, made of steel or of special wrought iron tested to the requirements of section II, the following formula is to be used :—

From Board of Trade "Standard Conditions."

Equation 37.

$$W.P. = \frac{(D - \cdot 267)^2 \times 8250}{A}.$$

D is the diameter of the stay over the thread in inches.

A is the area in square inches supported by one stay.

But in no case must the stress exceed 9,000 lbs. per square inch of section.

33. *Copper stays to fireboxes.*—For copper screw stays a stress of 5,500 lbs. per square inch of net section may be allowed.

From the National Boiler Insurance Company's Rules and from practice.

34. *Steel longitudinal stays.*—For steel longitudinal stays with threads not coarser than 6 threads per inch, the working pressure is to be calculated from the following formula :—

From Board of Trade "Standard Conditions."

Equation 38.

$$\text{W. P.} = \frac{(\text{D} - \cdot 34)^2 \times 9500}{\text{A}} \times \frac{\text{S}}{28}.$$

D is the the diameter of the stay over the thread in inches.

A is the area in square inches supported by one stay.

S is the minimum tensile breaking strength of the steel in tons per square inch.

But in no case must the stress exceed 11,000 lbs. per square inch of section when steel of a minimum tensile breaking strength of 28 tons per square inch is used.

In cases where longitudinal stays are made with enlarged ends and the body of the stay is smaller in diameter than at the bottom of the thread, and in cases where coarser threads than 6 per inch are used, the working pressure is to be calculated from the following formula :—

Equation 39.

$$\text{W. P.} = \frac{(\text{D}_1 - \cdot 125)^2 \times 9500}{\text{A}} \times \frac{\text{S}}{28}.$$

D_1 is the diameter of the stay at the bottom of the thread or at the smallest part of the body.

35. *Stress on stay tubes.*—On stay tubes whether of wrought iron or of lap-welded steel, a working stress of 7,500 lbs. per square inch of the net sectional area at the bottom of the thread is permitted.

From Board of Trade "Standard Conditions."

36. *Standard threads of screw and other stays.*—All longitudinal stays and screw stays should have threads in accordance with the British standard specification, true to pitch, *viz.* :—

From Board of Trade "Standard Conditions."

All screw stays $1\frac{1}{4}$ inch in diameter and upwards should have 9 threads per inch, and all stays 2 inches in diameter and above passing through plates and secured by nuts on each side of the plate should have not more than 6 threads per inch.

It is desirable that the threads of all screw stays should be turned off between the parts fitting into the plates.

It is desirable also that the outer ends of screw stays should have a hole 3/16 inch diameter drilled axially to a distance $\frac{1}{2}$ inch beyond the inner face of the outside plates.

37. *Stays not to be welded. Annealing of fireworked stay bars.*—No steel stays are to be welded. If plus threads are desired, the ends of the stay bars may be upset or the bars may be drawn down in the central portions from bars originally of the size of the ends. In either of these two cases the bars must be subsequently annealed throughout.

From Board of Trade "Standard Conditions."

In boilers over 12 feet in length between end plates the through longitudinal stays must be supported at or near the middle of their length.

38. *Longitudinal stays between tube plates.*—Where jointed longitudinal stays are fitted between the front and back tube plates or elsewhere, it is desirable that they should be fitted with pins having an effective sectional area 25 per cent. in excess of that of the stay. The pins may be slack in the holes, the total slackness being not more than 1/16 inch. The pins must be as close as possible to the shoulder of the eye forging. The shoulder of the forging should be at least $\frac{1}{2}$ inch wide all round, *i.e.*, the diameter at the shoulder must be not less than the diameter of the hole *plus* 1 inch.

From Board of Trade "Standard Conditions."

39. *Stay tubes.*—Stay tubes are to be screwed at both ends with continuous threads, and the holes in the tube plates are to be tapped with continuous threads. The stay tubes are to be expanded by roller expanders and not made tight by caulking only.

From Board of Trade "Standard Conditions."

40. *Minimum thickness of stay tubes.*—The minimum thickness of stay tubes measured under the threads shall be $\frac{1}{4}$ inch for marginal stay tubes and $\frac{5}{16}$ inch for other stay tubes.

From Board of Trade "Standard Conditions."

For small boilers the minimum thickness of stay tubes, whether marginal or otherwise, shall be $\frac{5}{16}$ inches.

From Bombay Revised Rules and practice.

41. *Thickened ends.*—If stay tubes are required to have their thickness increased at the screwed ends so that the thickness at the bottom of thread is practically the same as in the body of the tube, the thickening is to be attained by upsetting and not by any welding process, and the tubes are to be annealed after the upsetting.

From Board of Trade "Standard Conditions."

42. *Stays in compression.*—The same stress shall be allowed in compression as in tension and shall be calculated on the net section of the stay except where otherwise laid down.

From Bombay Revised Rules and practice.

43. *Nuts to screw stays.*—Nuts to screw stays in combustion chambers and fire boxes shall not be less and need not be more than $\frac{3}{4}$ inch thick for stays up to $1\frac{1}{2}$ inches diameter over threads, $\frac{7}{8}$ inch thick for $1\frac{5}{8}$ and $1\frac{3}{4}$ inch stays, 1 inch thick for $1\frac{1}{8}$ and 2-inch stays, and $1\frac{1}{8}$ inch thick for stays over 2-inch in diameter.

From Board of Trade "Standard Conditions."

The nuts for longitudinal stays shall be according to the British Standards appropriate to the diameters of the stays, the outside nut having the thickness therein prescribed for ordinary nuts, and the inside nuts having the thickness provided for lock nuts.

The nuts shall be made of solid mild steel or of iron which must be without weld when exposed to flame.

44. *Areas in upper spaces of flat end plates of locomotive type and vertical boilers supported by stays.*—When the areas supported by stays are semi-circular as in the upper parts of end plates and smoke box tube plates of locotype boilers, or annular as in the crown plates of vertical type boilers A, the area to be supported by stays, should, in the first case, be the area of the plate contained within the margins credited to casing or barrel sides, screw stays, fire door ring or tube stays as the case may be, and in the second case as the area of the annulus between the margins credited to uptake and shell. When bolt staying is necessary the stays must be properly distributed. The aggregate stay section may then be used in the formula.

From Bombay Revised Rules and practice.

45. *Diagonal bar or rod stays.*—The sectional area of a diagonal rod or bar stay should bear the same proportion to that of a direct stay as the length of the diagonal stay bears to the length of the perpendicular line from the end of the diagonal stay to the surface supported. The ends of diagonal stays should not be bent but should be attached to the plate with bevelled washers and nuts or with riveted tee blocks or angles and shackle pins (see Clause 38 for eyes and pins).

From Bombay Revised Rules and practice.

The section of least strength whether of stay, rivets, shackle or pin should be used in determining the working pressure.

46. *Gusset stays of Lancashire and Cornish boilers.*—Gusset stays should be attached to end and shell plates by double angles, not less in thickness than the gusset plates with properly spaced and formed rivets.

From Bombay Revised Rules and practice with increases in the stresses allowed for plates and rivets.

The working pressure for the stay when of ordinary form is to be calculated by the following formula :—

Equation 40.

$$\text{W. P.} = \frac{8500 \times C}{A}$$

C the co-efficient, is the number representing the least of the following :—

(1) $N_1 \times A_1$

(2) $N_2 \times A_2 \times 1{\cdot}75$

(3) $N_3 \times A_3 \times 1{\cdot}75$.

(4) $N_4 \times A_4$

(5) $(G - N^2 \times D^2) \times (t - 2) \times {\cdot}037$.

(6) $(G_1 - D_3) \times (t - 2) \times {\cdot}037$

N_1, N_2, N_3, N_4, D_1, D_2, D_3, D_4 and A_1, A_2, A_3, A_4, are respectively the numbers, diameters and sectional areas of the rivets in the joints of each gusset stay, the order of the joints being (1), angle to end plate, (2), end plate angles to gusset, (3) shell angles to gusset, and (4), angles to shell.

G in the depth in inches of gusset plate measured through the line of rivets attaching it to the end plate angles.

G_1 is the depth in inches of gusset plate measured normal to the slant edge of plate through the rivet nearest to the end plate in the joint attaching gusset plate to shell angles.

A is the area in inches of flat plate suppported by the gusset stay which, in the case of Lancashire and Cornish boilers, should be determined as follows :—

The margins allowed under flat plate rules for shell and furnace should be marked on end plates and the lengths of the centre lines of gussets between them measured, also the distance between each pair of gusset lines from the middle of the smaller in a direction normal to the greater.

If L and L_1 be the lengths of two adjacent gusset lines and if the distance between them be W, the area contained by the gusset lines and the shell and furnace margin lines may be apportioned between the stays thus :—

Equation 41.

$$\frac{W\ (3\ L + L_1)}{8} = \text{Portion of area in square inches apportioned to L line gusset.}$$

Equation 42.

$$\frac{W\ (3\ L_1 + L)}{8} = \text{Portion of area in square inches apportioned to } L_1 \text{ line gusset.}$$

The portion of the area on the other side of each gusset line should except when of triangular form, be found in like manner and its amount added to that already found to form the total.

For the triangular portions in the wing spaces the area should be taken as half the product of the length of gusset line into the perpendicular distance between it and the intersecting point where the marginal curves meet.

47. *Bolts or studs for ends, covers and small shells.*—The working pressure for bolts and studs of steel or wrought iron for circular ends, covers and small shells should be calculated by the following formula :—

From the National Boiler Insurance Company's Rules and Bombay Revised Rules and practice.

Equation 43.

$$W.P. = \frac{A \times S}{A_1 (A_1)}$$

A is the aggregate area of the net bolt section in square inches,

S is the stress allowed per square inch of bolt section as follows :—

¾	inch diameter, over threads,	. . . . .	. . .	3,000 lbs.
⅞	,,	,,	,,	. . . . .	. . .	4,000 ,,
1	,,	,,	,,	. . . . .	. . .	5,000 ,,
1⅛	,,	,,	,,	. . . . .	. . .	5,500 ,,
1¼	,,	,,	,,	. . . . .	. . .	6,000 ,,
1⅜	,,	,,	,,	. . . . .	. . .	6,500 ,,
1½	,,	,,	,,	. . . . .	. . .	7,000 ,,

A_1 is the area in square inches of the surface supported by the bolts which, when the bolts are at the outer edge only, should be taken as the area of a circle having a diameter midway between that of the bolt circle and that of the inner side of the shell or flange carrying the bolts.

Areas occupied or supported by tubes within the containing surface should be deducted. No bolt or stud below ¾ inch over threads is permitted to be used in boilers.

48. *Round or flat bar link stays or slings.*—For round or flat bar link stays or slings of steel, stresses of 9,000 and 8,000 lbs. per square inch of net section may be allowed in tension and shear respectively.

From Bombay Revised Rules and practice.

Fire Box and Combustion Chamber Top Supports.

49. *Girders supporting the tops of fire boxes and cumbustion chambers.*—For girders supporting the tops of fire boxes and cumbustion chambers the following formulæ are to be used :—

The first formula is adapted from the Board of Trade "Standard Conditions" with an increase of nearly 20 per cent. in pressure allowed. The "Standard Conditions" formula is practically the same as the one the Board of Trade and Lloyds Register have had in force for many years. An advance is desirable and from experience one of 20 per cent. can safely be made in the case of land boilers.

(*a*) Solid or split girders of rectangular section supported at ends only :—

Equation 44.

$$W.P. = \frac{C \times t \times D^2 \times S}{(L-P) \times D_1 \times L}$$

(*b*) Girders of I or other section supported at ends only :—

Equation 45.

$$W.P. = \frac{C_1 \times S}{(L-P) \times D_1 \times L} \times \frac{I}{Y}$$

The second formula is from the Bombay Rules and is intended for girders of any section. The pressure allowed by it is precisely the same as by the first.

t is the thickness of the girder at centre when a forging or casting, or the sum of the thicknesses of the plates where the girder is made of two plates, measured in 32nds of an inch.

D is the depth of the girder at middle in inches,

L is the length of the girder in inches, measured between the tube plate and fire hole or back plate, or between tube plates in chambers common to two opposite furnaces,

P is the pitch of the stays supported by the girder, in inches,

D_1 is the distance apart of the girders, centre to centre, in inches,

S is the minimum tensile breaking strength of the plates forming the girder in tons per square inch.

In the case of forged girders S is to be taken as 24 for iron and 28 for steel. For cast steel girders S is to be taken as 26 when no tests are produced,

I is the moment of inertia of section round neutral axis, expressed in inches,

Y is the distance in inches of the farther edge of section from neutral axis,

$C = \frac{N}{N+1} \times 21$, when the number of stays in each girder is odd, and $\frac{N+1}{N+2} \times 21$, when the number of stays in each girder is even, N being the number of stays to each girder.

$C_1 = 4030$ when the number of stays in each girder is odd, and $\frac{N+1}{N+2} \times 4030$ when the number of stays in each girder is even, N being the number of stays to each girder.

From Bombay Revised Rules and Practice.

Where girders rest on end or side plates of fire-boxes, etc., they should be directly fitted and bedded to the edges and corners of the supporting plates.

Where girders are supported in any other way than by the end or side plates of the fire-box or combustion chamber, the calculations for determining the working pressure should be made in accordance with the changed conditions of support.

In such cases the length of the strip of fire-box or combustion chamber top plate to be supported by the girder should, subject to the limit imposed on the distance of the nearest stay, be taken as equal to the product of the number of bolts carried by the girder into the pitch of the bolts. A nominal stress of 14,000 lbs. per square inch of girder section may be allowed for steel.

Slings, links, pins, rivets and connections to shell of slung girders should be sufficiently strong to carry the whole load that would otherwise be carried by the girder, and each girder must be equally slung or supported.

In the case of girders supported at the ends only by angle bars riveted to the casing crown, the length L of the girder may, when the girder extends over the full breadth of the angle face, be taken as the distance between the centres of the angle faces. When this distance does not exceed that of L in the formula the pressure is to be determined in the ordinary way.

The supporting angles and rivets must be of sufficient section for the intended purpose.

50. *Spacing of Ends Stays. Allowance for curves, etc.*—For the tops of fire-boxes and combustion chambers, the distance between the rows of stays nearest to the tube plate or fire hole plate or back plate as the case may be, and the commencement of curvature of these plates at their flanges shall not be greater than A in the flat plate rule.

From Board of Trade "Standard Conditions."

Where the tops are joined to the sides by curved portions, if the outer radius of the curved portion is less than half the allowable distance between the girders, the distance between the first girder and the inner surface of the side plate should not exceed the allowable distance between the girders. If the radius of the curved portion is greater than half the allowable distance between the girders, the width of the flat portion measured from the centre of the girder should not be more than half the allowable distance between the girders. The working pressure for the supporting bolts and for the plate between them should be determined in the ordinary way.

From Board of Trade "Standard Conditions" with co-efficient derived from test and calculations of German Professors controlling the German Boiler Regulations and from Bombay practice.

51. *Cambered Fire Box Tops.*—For Marshall Sons and Company's Patent Cambered Fire Box Tops the working pressure should be determined by the following formula :—

Equation 46.

$$W.P. = \frac{50\ (t-1)^2}{D^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots$$

t is the thickness of the cambered plate in 32nds of an inch,

D is the diameter of the largest circle that can be drawn passing through the centre lines of ribs and rivets or commencement of curvature at sides.

52. *Corrugated Fire Box Tops.*—For Garrets Patent Corrugated Fire Box Roof plates the working pressure should be determined by the following formulæ; the least pressure obtained by either formula to be taken :—

These formulæ are from Board of Trade "Standard Conditions" with co-efficients determined from practice.

Equation 47.

$$W.P. = \frac{C\ (t-1)^2}{(L+24) \times R} \quad \ldots\ldots\ldots\ldots$$

Equation 48.

$$W.P. = \frac{C_1}{R} \times \left[10\ (t-1) - L \right] \quad \ldots\ldots\ldots\ldots$$

t is the thickness of the corrugated plate in 32nds of an inch,

L is the length of the roof plate between centre lines of rivets in inches,

R is the external radius of the side corrugations at the middle of the length in inches.

C = 363 where the roof and side plates are in one piece and 325 where they are riveted.

C_1 = 12·5 where the roof and side plates are in one piece and 11·25 where they are riveted.

Tube Plates.

53. *Parts to be stayed.*—All flat tube plates, except those of loco-type boilers and of vertical boilers not exceeding 3 feet in diameter with vertical smoke tubes, must be stayed within the nests of tubes.

From general practice and experience.

The parts of tube plates which lie outside the nests of tubes must be stayed or supported wherever the size of the area of plate subject to steam pressure necessitates staying or support.

54. *Minimum thickness and Cross-Section.*—To provide a secure attachment for plain tubes in the tube plates the thickness of steel tube plates must not be less than—

From German Boiler Regulations.

Equation 49.

·125 D + ·2 = minimum thickness in inches.

and the cross section of the plate between any two holes must not be less than—

Equation 50.

·17 D + ·025 = minimum cross section in square inches.

For copper tube plates the minimum thickness and cross section are respectively.

Equation 51.

·2 D + ·4 = minimum thickness in inches.

Equation 52.

·527 D — ·263= minimum cross section in square inches.

D is the diameter in inches of the tube at the part of attachment to tube plate.

55. *Holding power of Plain Tubes.*—Where tube plates are not specially stayed in nests of tubes, the working pressure, based on the holding power of the tubes, must not exceed that found by the following formula:—

Adapted from German Boiler Regulations and from Bombay Revised Rules and practice.

Equation 53.

$$W.P. = \frac{C \times D}{A}.$$

D is the diameter of tube at the part of attachment to tube plate, in inches.

A is the area in square inches of tube plate supported by each tube, which generally may be taken as the product of the horizontal and vertical pitches of the tubes less the area of the tube itself.

C is a co-efficient which = 470 for tubes expanded into parallel holes and 530 for tubes expanded into taper holes.

The tubes at the fire-box end must in every case be beaded over.

In the unstayed tube plates of loco-type boilers the support afforded by the plain tubes must not be taken to extend beyond the lines enclosing the outer edges of the tubes. Parts of flat plate outside this line must either lie in the plate margin or be separately supported.

No account need be taken of the stiffness of tube plate in the nests of tubes, when the above conditions are fulfilled.

56. *Tube Plates of Vertical Boilers forming parts of Outer Shell.*—When vertical boilers have a nest or nests of horizontal tubes so that there is direct tension on the tube plates due to the vertical load on the boiler ends, or to their acting as horizontal ties across the shell, the thickness of the tube plates and the spacing of the tubes must be such that the section of metal taking the load is sufficient to keep the stress within that allowed on the shell plates.

From Board of Trade "Standard Conditions" Formula modified to reduce numerical factors.

Further, each alternate tube in the outer vertical rows of tubes must be a stay tube. The tube plates between the stay tubes must be in accordance with the rules for tube plates as in clause 54 and in addition.

Equation 54.

$$W.P. = \frac{17{\cdot}24 \ (t - 2) \times (P - D) \times S}{R \times P}.$$

t is the thickness of the tube plate in 32nds of an inch,

P is the vertical pitch of the tubes in inches,

D is the diameter of the tube holes in inches,

S is the minimum tensile breaking strength of the tube plates in tons per square inch,

R is the radial distance of the centre of the outer row of tube holes from the axis of the shell in inches.

57. *Compression on Tube Plates.*—The working pressure to be allowed for fire box or combustion chamber tube plates, which are subject to compression due to the pressure on the roof plate is to be determined by the following formula.

Adapted from Board of Trade "Standard Conditions" and Bombay Revised Rules and practice.

Equation 55.

$$W.P. = \frac{C \times (P - D) \times t}{L \times P}.$$

t is the thickness of the tube plate in 32nds of an inch,

P is the pitch of the tubes in inches, measured horizontally where the tubes are chain pitched, and diagonally where the tubes are zigzag pitched and the diagonal pitch is less than the horizontal,

D is the internal diameter of the plain tubes in inches,

L is the internal length of the fire-box or combustion chamber in inches measured at top between tube plate and firehole plate or back plate, or between tube plates in double ended boilers with combustion chambers common to two opposite furnaces,

C = 875 for steel and 344 for copper.

The above formula is not applicable in the case of fireboxes where the girders do not rest on the tube plate, or where the roof plate is stayed direct to the outer shell or to girders supported by the shell.

FURNACES.

58. *Plain Furnaces of Horizontal Boilers.*—The working pressure to be allowed on plain furnaces or furnaces strengthened by Adamson or other joints, and on the semi-cylindrical tops of fire-boxes and bottoms of combustion chambers where the sides are securely stayed, is to be determined by the following formulæ, whichever is less.

From Board of Trade "Standard Conditions;" wording altered to include parts of land boilers.

Equation 56.

$$W.P. = \frac{C}{D} \times \frac{(t-1)^2}{L+24}.$$

Equation 57.

$$W.P. = \frac{C_1}{D} \times \left[10\,(t-1) - L \right].$$

D is the external diameter of the furance or chamber top or bottom in inches,

t is the thickness of the furnace plate in 32nds of an inch,

L is the length of the furnace or other part in inches measured between points of substantial support, *i.e.*, centres of rows of rivets in end seams or commencement of curvature of flange, whichever is applicable,

C = 1450 where the longitudinal seams are welded and 1300 where they are riveted,

C_1 = 50 where the longitudinal seams are welded and 45 where they are riveted.

59. *Corrugated Furnaces of Horizontal Boilers.*—The working pressure to be allowed on corrugated furnaces is to be determined by the following formula.

From Board of Trade "Standard Conditions."

Equation 58.

$$W.\ P. = \frac{C\,(t - 1)}{D}.$$

D is the external diameter in inches measured at the bottom of the corrugations,

t is the thickness of the furnace plate in 32nds of an inch measured at the bottom of the corrugation or camber,

C.=480 for the Fox, Morrison, Deighton, Purves and other similar furnaces, and 510 for the Leeds Forge Bulb Suspension Furnace.

60. *Plain Furnaces of Vertical Boilers.*—The same formulæ as for the plain furnaces of horizontal boilers are to be used, but where the furnaces are tapered the diameter to be taken for calculation purposes shall be the mean of that at the top and of that at the bottom where it meets the substantial support from flange or ring. The length for the same purpose shall be the distance from the centre of the row of rivets connecting the crown and the body of the furnace to the substantial support at the bottom of the furnace, or to a row of screwed stays connecting the furnace to the shell, provided the pitch of stays at the furnace does not exceed 14 times the thickness of the furnace plate when the stays are riveted at their ends, or 16 times when the stays are fitted with nuts. Such screwed stays must be in diameter over the threads not less than $2\frac{1}{4}$ times the thickness of the furnace plate.

From Board of Trade "Standard Conditions."

61. *Hemispherical Furnaces of Vertical Boilers.*—When furnaces are hemispherical in form and subject to pressure on the convex side and are without support from stays of any kind,

From Board of Trade "Standard Conditions."

Equation 59.

$$W.\ P. = 275\ \frac{(t - 1)}{R}.$$

t is the thickness of the top plate in 32nds of an inch.

R is the outer radius of curvature of the furnace in inches.

For the ogee ring which connects the bottom of the furnace to the shell and sustains the whole load on the furnace vertically :—

Equation 60.

$$W.\ P. = \frac{140\ (t - 1)^2}{D\ (D - D_1)}.$$

t is the thickness of the ogee ring in 32nds of an inch,

D is the inside diameter of the boiler shell in inches,

D_1 is the outside diameter of the lower part of the furnace where it joins the ogee ring.

No furnace whether plain or corrugated should exceed 26/32nds inch in thickness, and all circular sectioned furnaces when new should be as near the truly circular form as the type of joint will permit.

From the Board of Trade "Standard Conditions." From practice.

For new furnaces with welded or butted joints a difference of not more than 1/8th inch in the cross gaugings of any one section shall be allowed. Rivet holes are to be drilled as in the case of shells.

Where cross tubes are fitted they shall be riveted and not welded to the furnace tube. The longitudinal seams of cross tubes may be welded; the weld is not to be exposed to the direct impact of flame. No allowance is to be made for cross tubes in calculating the strength of the furnaces in which they are fitted.

From Bombay Revised Rules and practice.

62. *Uptakes of Vertical Boilers.*—The working pressure for uptake tubes of vertical boilers is to be determined by the formulæ for plain furnaces, but only half the least pressure so found is to be allowed for uptake tubes.

From Bombay Revised Rules and practice.

When crown plates of vertical boilers are not fitted with smoke tubes, the uptake tubes in their capacity as stays should be strong enough to satisfy the following rule:—

Equation 61.

$$W.P. = \frac{A \times S}{A_1}.$$

A is the area of net section of tube or of rivets or bolts connecting uptake to furnace or shell crown plates in square inches, whichever is least

A_1 is the area in square inches of the annular surface around the uptake tube which, when no bolt or other stays are fitted, may be taken as extending to midway between inside of shell and waterside of uptake, but in no case beyond what would be allowed under flat plate rules for margins and measured accordingly.

Where bolt stays are fitted, the surface to be supported by the uptake may be taken as that within the inner circle of the annulus supported by the stays.

S is the stress allowed per square inch of net section of material which, for the tube itself, may be 4,000 lbs. and for rivets 7,000 lbs. in either shear or tension.

These requirements apply equally either to flat or dished crown plates.

Manholes, Doors and Stand Blocks.

63. *Means for Examination and Cleaning.*—All boilers should have, where possible, means for ingress whereby examination and cleaning of the inner surfaces of plates and tubes exposed to flame may be thoroughly effected. When boilers are too small to permit of this, they must be constructed so as to be easily taken apart or there must be manholes and sightholes sufficiently large and numerous to permit of the inside being satisfactorily cleaned.

From Board of Trades "Standard Conditions"

64. *Manholes and sightholes in Vertical Boilers.*—Where large cross tubes are fitted there must be a sighthole in the shell opposite at least one end of each tube sufficiently large to examine and clean it. The doors of these sight-holes must be in positions accessible for that purpose. In addition to the cross tube sight-holes there must be at least three mud-holes round the base of the boiler.

From Board of Trade "Standard Conditions."

From practice.

65. *Manholes, Mudholes and Sightholes in Locomotive Type Boilers.*—Wherever the size of the boiler permits there should be a manhole in the barrel. Barrels of 3 feet and upwards in diameter must have a manhole not less than 15 inches by 11 inches in the clear. Barrels between 2 feet and 3 feet in internal diameter must have a manhole not less than 14 inches by 10 inches in the clear. Barrels below 2 feet in internal diameter must have either a manhole or a sight-hole as large as practicable. The opening must not be less than 9 inches by 6 inches. There must also be a sight-hole or hand-hole at the bottom of each corner of the fire-box casing.

From experience and practice.

Wherever practicable the holes should be in the rounded corner and should be oval in shape with the major axis vertical. The holes should not be less than 5 inches by 3¼ inches in the clear wherever the size of the boiler permits.

66. *Standard sizes of Man-holes.*—Man-holes must be made true ellipses, standard sizes being 16″×12″, 15″×11″, and 14″×10″ in the clear.

From British Marine Engineering Design and Construction Committee's Report.

Oval manholes in cylindrical shells must have their shorter axes arranged longitudinally.

From Board of Trade "Standard Conditions."

67. *Standard Sizes of Mudholes and Sightholes.*—Mudholes and sightholes must be true ellipses. Standard sizes are 9″×6″, 7″×5″, and 5″×3½″.

From British Marine Engineering Design and Construction Committee's Report.

68. *Compensation Rings to Manholes.*—Where manholes are fitted in cylindrical shells, they must have compensation rings of sufficient breadth and thickness properly riveted to the shell plates. The whole net sectional area of the strengthening rings and the number and area of the rivets securing them to the shell plate must in each case be sufficient to compensate for not less than the same fraction as that of the longitudinal joint of the portion cut out of the shell plate. The spacing of the rivets must be such as not to weaken the shell plate to a greater extent than the longitudinal seam.

From British Marine Engineering Design and Construction Committee's Report.

From Bombay Revised Rules and Practice.

The percentage of compensating section should be determined by the following formulæ :—

Equation 62.

$$\frac{200\ (W-D) \times Tr}{(L+2D) \times Ts} = \text{percentage strength of compensating section.}$$

Equation 63.

$$\frac{80 \times A \times N}{(L+2D) \times Ts} = \text{percentage strength of rivet section.}$$

Second formula is new.

W is the Width of compensation ring in inches measured on the longitudinal axis,

L is the Length of opening in shell in inches measured on the longitudinal axis,

D is the Diameter of rivet holes in inches,

Tr is the Thickness of compensation ring in inches,

Ts is the Thickness of shell plate in inches,

A is the Area of one rivet hole in inches,

N is the number of rivets on one side of the longitudinal line.

Parts of raised manhole mouthpieces within four inches of the shell may, in addition to the ring, be included in the compensating section.

69. *Compensation for cutting Large Holes in Shells.*—Where holes are cut in cylindrical shells for mountings, the diameters of the holes being greater than 2½ times the thickness of the shell plate *plus* 2¾ inches, compensation must be fitted as in the case of manholes. Where ordinary sized steel stand blocks or pad pieces are fitted and are securely riveted to the shell no additional compensation for the

From Board of Trade "Standard Conditions."

From Bombay Revised Rules and practice.

hole cut in the shell is needed. If, however, the net section of the stand block or pad within four inches of the shell is less than the section of the shell plate cut away, a compensation ring must be fitted. Where a large opening is cut in a cylindrical shell to receive another part of the structure, the sides where cut away must be efficiently cross stayed or strengthened in some other effective manner.

70. *Manholes and Mudholes in Flat Plates.*—Where a flat plate is flanged to stiffen it at a manhole or sighthole, to permit the same working pressure as would be allowed upon an unpierced plate, the depth of the flange measured from the outer surface is to be at least equal to—

From Board of Trade "Standard Conditions."

Equation 64.

$$\sqrt{T \times W}.$$

where T is the thickness of the plate in inches, and

W is the minor axis of the hole in inches.

71. *Stand Blocks and Pads.*—Stand blocks and pad pieces for carrying mountings should be of wrought iron or mild steel, either pressed or welded, and of substantial proportions. They should be carefully bedded on the shell and the riveting should be pitched to ensure a tight joint. The jointing faces to which the mountings are to be bolted should be machined and be level when the boiler is in its working position.

From Bombay Revised Rules and practice.

72. *Doors, Mouthpieces and Cross Bars.*—All internally fitted doors of manholes, mudholes and sightholes, must be of wrought iron or steel built up or pressed to shape and annealed, or made from one thickness of plate with a machined recess for the jointing material. Their spigot part or the recess must not have a greater clearance than $\frac{1}{16}$th inch all round *i.e.*, the axes must not be less than $\frac{1}{8}$th inch smaller than the holes in which they are fitted.

From Board of Trade "Standard Conditions."

The studs of all doors should be screwed through the plate and be fitted with nuts on the inside, or bolts may be used screwed through the plate with the heads inside.

Manhole mouthpieces for cylindrical shells must be made of steel or wrought iron either pressed out of the solid or welded. Circular manhole mouthpieces of Lancashire type boilers should not be less than $\frac{3}{4}$ inch in thickness, and when welded the position of the weld should be at right angles to the longitudinal line. Cross Bars must be of substantial proportions and may be either solid, forgings of steel or iron or be of cast steel.

From Bombay Revised Rules and practice.

Boiler Mountings and Fittings.

73. *The Requisite Mountings and Fittings.*—Every boiler must be fitted with the following.

From Bombay Revised Rules.

Two safety valves;

Two independent means of indicating the water level;

A steam pressure gauge;

A steam stop valve;

A feed check valve;

A blow down cock or valve;

An attachment for Inspector's test gauge;

A manhole, where the size and construction permit; and such mudholes or sightholes as are necessary for effectively cleaning the boiler.

It is recommended that in Lancashire and Cornish boilers one of the safety valves should be of high-steam and low-water type and that all land boilers of ordinary type should have a fusible plug in each furnace.

74. *Safety Valves.*—Safety Valves shall be not less than 1 inch in diameter except in the case of very small boilers for which valves of $\frac{3}{4}$ inch diameter are permitted.

From Board of Trade "Standard Conditions."

The minimum aggregate area of safety valves of ordinary type in each boiler whether coal fired or oil fired and whether working under natural, forced or induced draught shall be found by the following formula:—

Equation 65.

$$A = H.S. \times \frac{K}{(W.P. + 15)}.$$

A is the aggregate area of safety valves in square inches.

H. S. is the total heating surface of the boiler in square feet,

(See Part II Section I, clause 4.)

W. P. is the working pressure in lbs. per square inch,

K=1·25 for coal fired boilers and 1·5 for oil fired boilers.

All the safety valves of a boiler may be fitted in one chest which must be separate from any other valve chest, and which must be connected direct to the boiler or stand block or pad by a strong and stiff neck, the passage through which should have a cross sectional area at least equal to one half the aggregate area of the safety valves in the chest.

The safety valves of small locomotive type boilers with overhead engines may, on account of cramped space, be attached to the engine cylinder casing provided there is a clear short passage way of ample sectional area and structural strength between the valves and the boiler.

From practice.

The openings in the boiler shell for safety valves must be left clear and uncovered on the inside and must not be connected to an internal pipe of any description.

From Bombay Revised Rules.

Each safety valve must have a lift at least equal to one-fourth of its effective diameter and there must be a free outlet for the waste steam.

From Bombay Revised Rules.

Where a waste steam pipe is fitted the pipe and the passages leading to it should have a cross sectional area not less in square inches than ·01 times the total heating surface of the boiler in square feet, but in no case should it be less than 1·1 times the combined areas of the safety valves as given by the above rule.

From Board of Trade "Standard Conditions."

Each large enclosed safety valve chest shall have a means of draining it, and the drain pipe shall be led clear of the boiler.

From Board of Trade "Standard Conditions."

Means must be provided in every case to prevent the valves being lifted out of their seats when working. The valve seats should be secured by studs and nuts.

From Bombay Revised Rules and practice.

In the case of lever valves, if the holes in the lever are not bushed with brass, the pins must be of brass; iron and iron working together must not be passed.

The weight of a lever and weight safety valve should be in one piece and be secured at the end of the lever against a change of position. In the case of spring loaded safety valves, washers or ferrules must be fitted under the adjusting screws so that the valves cannot be overloaded when under steam.

Safety valves must be accessible and so arranged that they can be eased off their seats at any time. In the case of dead weight and spring loaded safety valves a substantial test lever for the purpose must be provided.

The size of the steel of which the springs of direct loaded safety valves are made should be found by the following formula.

Equation 66.

$$\sqrt[3]{\frac{L \times D}{C}} = \text{Thickness of wire in inches.}$$

L is the load on the spring in pounds,

D is the diameter of the spring from centre to centre of wire in inches,

C=8,000 for round steel and 11,000 for square steel.

75. *Water Gauges.*—Every boiler must have two means of indicating the water level in it, and have marked on it when applicable in a contiguous position easily seen, the level of the highest part of the furnaces, fire box or combustion chamber as the case may be.

Adapted from Board of Trade "Standard Conditions," Bombay Revised Rules and practice.

All large boilers must be fitted with two glass water gauges. For small boilers where there is difficulty in fitting two glass water gauges, two test cocks may be fitted in place of the second glass water gauge.

The lowest visible part of the glass water gauge and lower test cock must be fixed at a safe working level. For locomotive type and vertical boilers this should not be less than 2 inches above the highest part of the fire box roof plate.

Glass water gauges must be placed so as to be easily seen and reached by the boiler attendant. The fittings of glass water gauges and test cocks must be of substantial make with large passage ways through them, and so constructed that an instrument can be passed through the opening whilst the boiler is under steam. The gauge cocks when open should have their handles in a vertical direction and each handle at its junction with the plug must be plainly marked with a deep line to indicate the direction of the passage way through the plug. A drain cock and pipe must be fitted to each glass water gauge. A glass guard to prevent injury to the attendant and a pointer to show the ordinary working water level must also be fitted to each glass water gauge.

76. *Steam Pressure Gauge.*—Each boiler shall have a separate steam pressure gauge placed where it can be easily seen. It must be marked in pounds per square inch and must have a range of not less than double the working pressure of the boiler. A red line should mark the working pressure and a syphon pipe must be fitted between the pressure gauge and the boiler.

From Board of Trade "Standard Conditions," Bombay Revised Rules and practice.

77. *Steam Stop Valve.*—A steam stop valve must always be fitted between the boiler and the steam pipe and, except in the case in which a super-heater forms an integral part of the boiler itself, between the boiler and the superheater. Where two or more boilers are connected with a steam receiver or any other vessel a steam stop valve must always be fitted between the boiler and such receiver or vessel.

From Bombay Revised Rules.

Steam stop valves must be attached direct to the boiler shell or to suitable pads or stand blocks riveted to the shell and the neck of the valve chest should be reasonably short and of strong construction. Exception to this rule will be made in the case of a large boiler in which it is proposed for the purpose of drainage or owing to obstruction, to connect the steam pipes to the steam stop valve at a higher level than would be obtained under the rule, in which case a vertical stand pipe not exceeding 5 diameters in height will be permitted between the stop valve and the boiler.

Such stand pipes must be of strong construction, of wrought iron, mild steel, or cast steel. The flanges of wrought iron or mild steel pipes should be riveted to the pipes, and there should be no branch on the stand pipe for any other connection.

Exception to the rule will also be made in the case of a large boiler in which it is desired to fit a tee piece for the purpose of providing a branch connection between the

stop valve and the boiler. Such a tee piece must be of strong construction, of wrought iron, mild steel, or cast steel and not exceed $2\frac{1}{2}$ diameters in height. A stop valve must be fitted direct to each tee piece branch.

78. *Feed Check Valve.*—The feed check valve must be attached direct to the boiler and be of combined non-return and shut down type. The valve opening in boiler or end of internal feed pipe should be above the low water level and below the working level.

From practice.

79. *Blow-down Cock or Valve and Pipes.*—The blow down cock or valve shall be of substantial construction and if the former, shall be fitted with a locking guard and box spanner which cannot be removed until the cock is closed.

From good practice and experience.

For locomotive type, vertical and marine type boilers, the cock or valve should be attached direct to the boiler. For water tube boilers the cock or valve should be outside the brickwork with a substantial steel pipe between it and the mudbox.

For Cornish and Lancashire boilers the cock or valve should be attached to a cast steel elbow pipe of substantial section, bolted to a suitable stand block riveted to the boiler. Cast iron elbow pipes are not permitted.

It is recommended that the waste pipe attached to the cock or valve should not be connected to a pipe common to another boiler. It should not be bound fast in earth or brickwork.

80. *Inspectors Pressure Gauge Attachment.*—Every boiler must be fitted with a valve or cock carrying in a vertical position a receiving screw for the attachment of the Inpectors pressure gauge.

From Bombay Revised Rules and good practice.

The cock or valve may form part of the pipe carrying the boiler pressure gauge. Where separate, it should be attached to the top of the shell near the pressure gauge.

The receiving socket shall be tapped $\frac{3}{8}$ inch Whitworth Thread and shall be fitted with an easily removeable cap.

For small boilers which cannot be entered by an Inspector and which are hydraulically tested at each inspection a plug hole tapped $\frac{3}{8}$ inch Whitworth thread should be provided in a handy position for the attachment of the Inspectors' test pump hose nipple.

81. *Manholes, Mudholes and Sightholes.*—See Section III, Clauses 63 to 72.

82. *Fusible Plugs.*—Plugs where fitted should be over the hottest part of the furnace or firebox. The outside and inside of the plug should be kept clean and the fusible metal should be periodically renewed.

From Bombay Revised Rules and good practice.

83. *Design of Boiler Mountings.*—All boiler-mounting valves over $1\frac{1}{2}$ inches diameter must have outside screws, their covers must be secured by bolts or studs, and all are to be arranged to be shut with a right hand motion of the wheels and must have means for clearly indicating whether they are open or shut.

From Board of Trade "Standard Conditions."

84. *Material of Valve Chests.*—All stop and safety valve chests and steam pipe fittings when subjected to saturated steam only may be made of cast iron, but such valve chests and steam pipe fittings when subjected to steam of a temperature above 425 degrees Fahr. must be of cast steel or other approved material.

From Board of Trade "Standard Conditions."

85. *Cocks and valves to be easily seen whether open or shut.*—The construction of all cocks and valves connected to the boiler must be such as to show without difficulty whether they are open or shut.

From Board of Trade "Standard Conditions."

86. *Studs and Bolts securing Mountings.*—When boiler mountings are secured by studs, the studs must have a full thread holding in the plate for a length of at least one diameter. If the stud holes penetrate the whole thickness of the plate, the stud must be screwed right through the plate and be fitted with a nut inside the boiler.

From Board of Trade "Standard Conditions."

Where bolts are used for securing mountings they must be screwed right through the plate with their heads inside the boiler.

87. *Bronze Boiler Mountings.*—The chests of blow down cocks and valves, water gauge valves and cocks, and similar fittings, must be made of good and suitable bronze. All cocks used with boilers working at 100 lbs. pressure or above should be asbestos packed and of substantial design and make.

From the British Marine Engineering Design and Construction Committee's Report.

Pipes and Tubes.

Steam and Water Pipes subject to Internal Pressure.

88. *Copper Tubes and Pipes.*—No pipe made from the electro-deposition of copper on a mandril shall be used for steam or feed delivery. All copper pipes must be properly annealed before putting in place. All copper steam and feed pipes subject to a pressure over 75 lbs. per square inch shall be solid drawn.

From Board of Trade "Standard conditions."

No steam pipe intended for a working presure of over 180 lbs. per square inch shall be made of copper when the internal diameter exceeds 5 inches. No copper pipe shall be used for super heated steam.

All copper steam pipes on completion and prior to being fitted in place shall be subjected to hydraulic test to at least twice the working pressure.

For all feed delivery pipes the test pressure shall be 2½ times the working pressure allowed on the boilers.

The working pressure of copper pipes shall be determined by the following formula—

Equation 67.

$$\text{W. P.} = \frac{(t-3)}{D} \times C.$$

D is the internal diameter of the pipe in inches.

t is the thickness of the pipe, in 100ths of an inch.

C = 6 for solid drawn steam pipes.

45 for brazed steam pipes.

48 for solid drawn feed pipes, and

36 for brazed feed pipes.

When copper pipes are bent they must be made thicker to provide for thinning at the bend. In no case should the radius of curvature at the centre line of the pipe be less than twice the external diameter of the pipe.

89. *Wrought Iron and Steel Pipes.*—Steam and other pipes may be made of wrought iron or wrought steel.

From Board of Trade "Standard Conditions."

The process of welding the seams shall be by hammering or rolling the joint.

On completion of any work which involves heating, whether for welding the joint welding on flanges, hot bending the pipe, or for any other purpose, the pipe shall be carefully annealed.

Mild steel for lap-welded steam pipes and tubes may have a tensile breaking strength not exceeding 28 tons per sq. inch, with a minimum elongation of 25 per cent. on the standard test piece. Feed pipes if made of steel should be solid-drawn and cold finished.

All iron or steel steam pipes and tubes prior to being fitted in place shall be subjected to hydraulic test to at least 3 times the working pressure.

All iron or steel feed delivery pipes shall be hydraulically tested to at least 4 times the working pressure of the boiler.

The working pressure allowed on pipes shall be determined by the following formulæ.—

(*a*) Solid drawn cold finished pipes (up to 28 tons tensile breaking strength).

Equation 68.

$$\text{W. P.} = \frac{(t-10)}{D} \times 120.$$

(*b*) Solid drawn hot finished pipes (up to 28 tons tensile breaking strength).

Equation 69.

$$\text{W. P.} = \frac{(t-12)}{D} \times 120.$$

(*c*) Welded pipes of iron or steel whether with or without covering strap.

Equation 70.

$$\text{W. P.} = \frac{(t-12)}{D} \times 90.$$

(*d*) Feed delivery pipes.

Equation 71.

$$\text{Boiler Pressure} = \frac{(t-8)}{D} \times 100.$$

(*e*) Pipes with riveted joints. (J being the strength of joint per cent. of the solid plate or strip).

Equation 72.

$$\text{W. P.} = \frac{(t-9)}{D} \times 1{\cdot}2 \times J.$$

From the British Marine Engineering Design and Construction Committee's Report.

No wrought iron or steel pipe shall be less in thickness than :—

Equation 73.

$$t = 5 \times \sqrt{D} + 2.$$

D is the internal diameter of the pipe in inches,

t is the thickness of the pipe in 100ths of an inch.

New formula adapted from flat plate and steam pipe rules of Board of Trade "Standard Conditions."

90. *Rectangular Section Pipes.*—Solid drawn or welded rectangular section steel pipes for headers, cross pipes and mud drums of water tube boilers should comply generally with the requirements for ordinary steel pipes, but the hydraulic test prior to being fitted in place need only be twice the working pressure of the boiler.

The working pressure of the pipe is to be determined by the formula :—

Equation 74.

$$\text{W. P.} = \frac{25}{D} \left[3(t-4) + \frac{(t-1)^2}{D} \right]$$

t is the thickness of the pipe in 32nds of an inch,

D is the internal diameter of side of the pipe in inches.

Steel and Wrought Iron Tubes.

91. *Material and Method of Manufacture.*—Both plain and stay smoke tubes may be made either of wrought iron or of mild steel lap welded.

Adapted from Board of Trade "Standard Conditions."

92. *Working Pressure for Plain and Stay Tubes.*—The working pressure for plain and stay tubes (as tubes not as stays) is to be determined by the following formula. No tube is to be less than 11 S. W. G. thick.

Equation 75.

$$\text{W. P.} = \frac{10{,}000\,(t - \cdot 085)}{D}.$$

T is the thickness of tubes in inches,

D is the external diameter of the tube in inches.

Diameters and thicknesses of Plain and Stay Tubes.—The following table may be worked to—

External diameter in inches.	Standard thickness in L. S. G. and fractions of an inch and Suitable Working Pressure.				
	11 (·116)″.	10 (·128)″.	9 (·144)″.	8 (·160)″.	7 (·176)″.
1″	310	430	...	...	...
1¼″	250	345	470	...	...
1½″	210	285	390	500	...
1¾″	180	245	335	430	500
2″	155	215	300	375	445
2¼″	140	190	260	315	395
2½″	125	175	230	300	350
2¾″	110	160	215	275	325
3′	100	140	190	250	300
3¼′	95	130	180	230	280
3½″	90	120	165	215	260

93. *Brass and Copper Tubes.*—The thickness of tapered brass and copper smoke tubes for locomotive boilers should not be less than 12 S. W. G. (·104 inch) at the smoke-box end and 10 S. W. G. (·128 inch) at the other, for tubes of 1½ inches to 1⅞ inches external diameter inclusive; and for tubes of 2 inches to 2¾ inches external diameter inclusive, the thickness at the smoke-box end should not be less than 11 S. W. G. (·116 inch) and 9 S. W. G. (·144 inch) at the other.

From the National Boiler Insurance Company's Rules.

From the British Marine Engineering Design and Construction Committee's Report.

94. *Size and Thickness of Flanges.*—The size and thickness of flanges and the number and size of their bolts shall be as prescribed by the Rules of the British Engineering Standards Association.

95. *Flanges of Copper Pipes.*—Flanges of copper pipes may be made of the usual brass or bronze or of wrought iron or of wrought or cast steel.

96. *Flanges of Iron and Steel Pipes.*—Flanges of iron and steel pipes may be made of cast steel, wrought iron or wrought steel made without a weld. When pipes are not more than 20/100 inch thick and not more than 9 inches in inside diameter they may be expanded by rollers into a flange having a series of recesses formed within it. When pipes are over 18/100 inch thick and not more than 12 inches in internal diameter they may be screwed into the flanges with a disappearing thread.

Flanges may be riveted, when practicable, to pipes of all sizes the thickness of which exceeds 20/100 inch.

Flanges made of iron or steel may be welded by any suitable process to pipes made of wrought iron, ingot iron or tube steel, and if the flanges are made of iron or tube steel they may be welded to mild steel pipes. When flanges are attached to pipes by brazing or welding they shall be also secured in such additional way, *e.g.*, by riveting the ends or forming a conical end so as to fit into a conical bore in the flange) that the resistance to withdrawal from the flange does not depend wholly on the brazing or welding.

From the British Marine Engineering Design and Construction Committee's Report.

97. *Cast Metal Pipes and their Equivalents as Cylindrical Parts of Mountings and Fittings.*—The above mentioned mountings and fittings may be made of cast steel, cast iron, or bronze.

98. *Cast Steel Chests, etc.*—Cast Steel shall be used instead of cast iron when the temperature to which they are exposed when at work exceeds 425 degrees Fahr.

Generally such steel castings should be made of a metal, the tensile breaking strength of which is not less than 28 nor more than 35 tons per square inch with an elongation of 15 per cent. in 2 inches. When the castings are intricate the tensile breaking strength may be higher so long as the elongation is not less than 12½ per cent. in 2 inches.

When machined and ready for fitting in place they shall be subjected to a hydraulic test equal to 3 times the working pressure which they may have to bear.

Steel castings which will be subject to the action of feed water should be made of steel of which the manganese content does not exceed ·4 per cent.

99. *Cast Iron Chests, etc.*—Cast iron for boiler mountings and fittings exposed to pressures exceeding 75 lbs. per square inch should have a tensile breaking strength of not less than 9 tons per square inch, and be subject to the following test.—

Bars 1½ inches square in section placed on knife-edged supports 6 inches apart shall withstand without fracture the impact of a 21 lbs. weight dropped four times from a height of 15 inches.

100. *Bronze Chests, etc.*—Bronze for all mountings and fittings should be of the Admiralty Composition, *viz.*, Cu. 87·5, Sn. 10, Zn. 2, and Pb. ·5 when subject to a temperature exceeding 350 degress Fahr.

Other good bronzes may be used for mountings and fittings if they are shown to be equally satisfactory.

Such bronzes shall have an ultimate tensile breaking strength of not less than 14 tons per square inch with an elongation of 10 per cent. in 2 inches when at a temperature of 550 degrees Fahr.

Good commercial bronze for general purposes should have a tensile breaking strength of not less than 14 tons per square inch with an elongation of 10 per cent. in 2 inches when at a temperature of 350 degrees Fahr.

Such bronze castings must be certified by the manufacturers as possessing these characteristics, and that after being machined they have been tested to twice the working pressure, and feed delivery fittings to 2½ times the boiler pressure, with satisfactory results both as to strength and tightness.

All such chests and fittings must be smooth, sound and free from flaws, cracks, blow-holes or other injurious defects. Their working pressure and thickness shall be determined by the following formulæ—

Equation 76.

$$W.\ P. = \frac{(t - X)}{D} \times C.$$

Equation 77.

$$t = \frac{W.\ P. \times D}{C} + X.$$

The minimum thickness of cast metal chests, etc., and their equivalents shall be :—

When of Cast steel, $t = 2{\cdot}5\sqrt{D} + 6$

When of Cast iron, $t = 2{\cdot}5\sqrt{D} + 4$

When of Cast Bronze, $t = 2{\cdot}5\sqrt{D} + 2$

D is the internal diameter of the chest in inches,

t is the thickness of the chest in 32nds of an inch,

C is a co-efficient from the following table,

X is a provision for toleration, etc., from the following table.

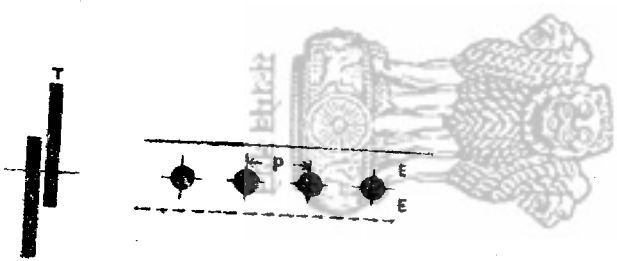
Table of Values of C. and X.

Material of casting.	C.	X.
Cast steel, 28/35 tons tensile strength	400	8
Cast iron, at least 9 tons tensile strength	200	6
Bronze, Admiralty and equally good	220	4
Bronze, good mercantile	175	4
Bronze, Commercial, quality unknown	150	4

Diagrams of Riveted Joints with Formulae.

SINGLE RIVETED JOINTS.

FIG. 1. LAP JOINT. ONE RIVET PER PITCH.



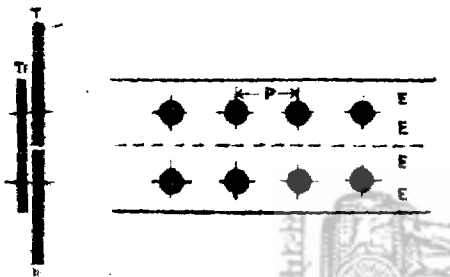
Max. Pitch $= 1{\cdot}31 \times T + 1{\cdot}625.$

Plate % $= \dfrac{100\ (P - D)}{P}$

Rivet % $= \dfrac{100 \times A \times S_1}{P \times T \times S}$

E $= 1{\cdot}5 \times D$.

FIG. 2. SINGLE BUTT STRAP. ONE RIVET PER PITCH.



Max. Pitch $= 1{\cdot}53 \times T + 1{\cdot}625$

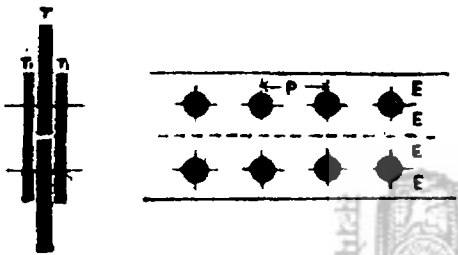
Plate % $= \dfrac{100\ (P - D)}{P}$

Rivet % $= \dfrac{100 \times A \times S_1}{P \times T \times S}$

E $= 1{\cdot}5 \times D$

BUTT STRAP $= 1{\cdot}125 \times T$

FIG. 3. DOUBLE BUTT STRAP. ONE RIVET PER PITCH.



Max. Pitch $= 1{\cdot}75 \times T + 1{\cdot}625$

Plate % $= \dfrac{100\ (P - D)}{P}$

Rivet % $= \dfrac{100 \times A \times 1{\cdot}875 \times S_1}{P \times T \times S}$

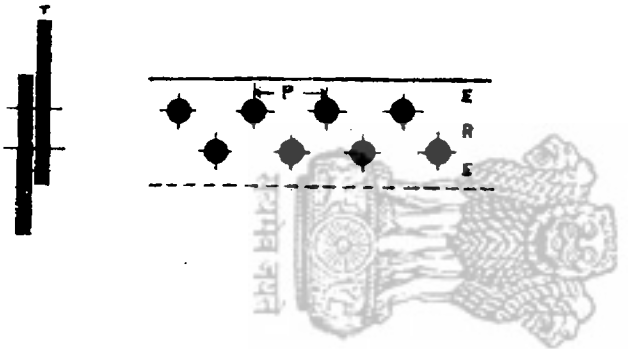
E $= 1{\cdot}5 \times D$

BUTT STRAPS $= {\cdot}625 \times T$

DOUBLE RIVETED JOINTS.

Fig. 4.

LAP JOINT. TWO RIVETS PER PITCH.



$$\text{Max. Pitch} = 2{\cdot}62 \times T \times 1{\cdot}625$$

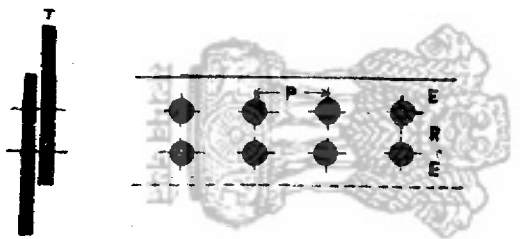
$$\text{Plate } \% = \frac{100\ (P - D)}{P}$$

$$\text{Rivet } \% = \frac{100 \times A \times 2 \times S_1}{P \times T \times S}$$

$$R = {\cdot}33\ P + {\cdot}67\ D$$

$$E = 1{\cdot}5 \times D$$

FIG. 5. LAP JOINT. TWO RIVETS PER PITCH.



Max. Pitch $= 2{\cdot}62 \times T + 1{\cdot}625$

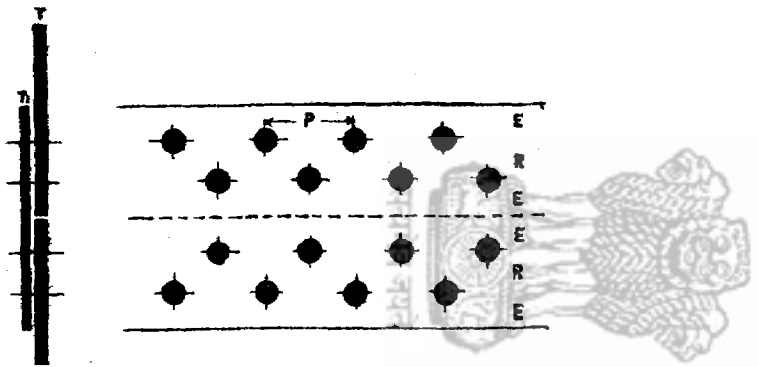
Plate % $= \dfrac{100\ (P - D)}{P}$

Rivet % $= \dfrac{100 \times A \times 2 \times S_1}{P \times T \times S}$

R $= 2 \times D$

E $= 1{\cdot}5 \times D$

FIG. 6. SINGLE BUTT STRAP. TWO RIVETS PER PITCH.



Max. Pitch = $3{\cdot}06 \times T + 1{\cdot}625$

Plate % = $\frac{100\ (P-D)}{P}$

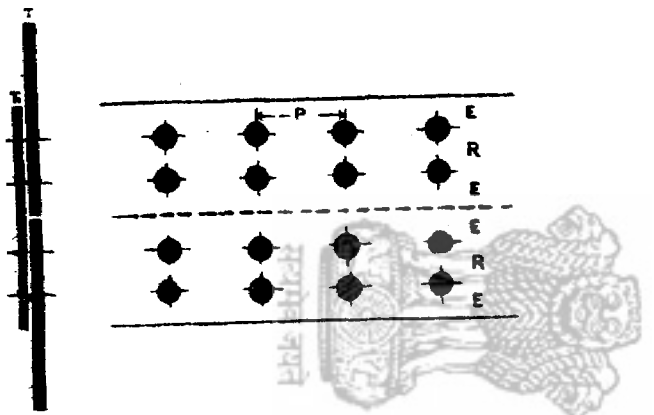
Rivet % = $\frac{100 \times A \times 2 \times S_1}{P \times T \times S}$

R = $\cdot 33\ P + \cdot 67\ D$

E = $1{\cdot}5 \times D$

BUTT STRAP = $1{\cdot}125 \times T$

FIG. 7. SINGLE BUTT STRAP. TWO RIVETS PER PITCH.



Max. Pitch = $3{\cdot}06 \times T + 1{\cdot}625$

Plate % = $\frac{100\ (P-D)}{P}$

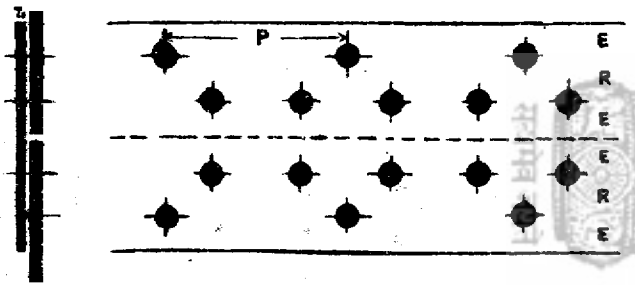
Rivet % = $\frac{100 \times A \times 2 \times S_1}{P \times T \times S}$

R = $2 \times D$

E = $1{\cdot}5 \times D$

BUTT STRAP = $1{\cdot}125 \times T$

FIG. 8. SINGLE BUTT STRAP. THREE RIVETS PER PITCH.



$$\text{Max. Pitch} = 4{\cdot}05 \times T + 1{\cdot}625$$

$$\text{Plate \%} = \frac{100\,(P-D)}{P}$$

$$\text{Rivet \%} = \frac{100 \times A \times 3 \times S_1}{P \times T \times S}$$

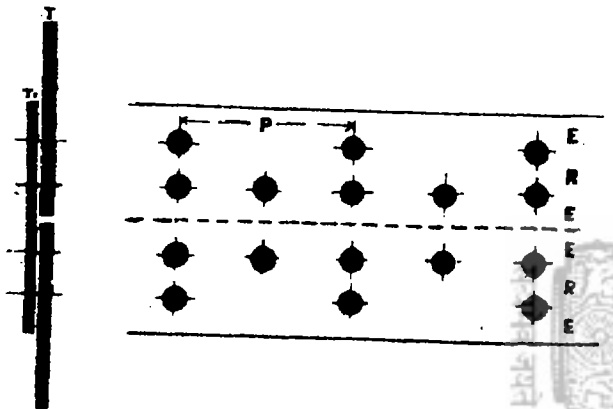
$$\text{Combined \%} = \frac{100\,(P-2\,D)}{P} + \frac{100 \times A \times S_1}{P \times T \times S}$$

$$R = {\cdot}2\,P + 1{\cdot}15\,D$$

$$E = 1{\cdot}5 \times D$$

$$\text{BUTT STRAP} = 1{\cdot}125\,T \times \frac{(P-D)}{(P-2\,D)}$$

FIG. 9. SINGLE BUTT STRAP. THREE RIVETS PER PITCH.



$$\text{Max. Pitch} = 4{\cdot}05 \times T + 1{\cdot}625$$

$$\text{Plate \%} = \frac{100\,(P-D)}{P}$$

$$\text{Rivet \%} = \frac{100 \times A \times 3 \times S_1}{P \times T \times S}$$

$$\text{Combined \%} = \frac{100\,(P-2\,D)}{P} + \frac{100 \times A \times S_1}{P \times T \times S}$$

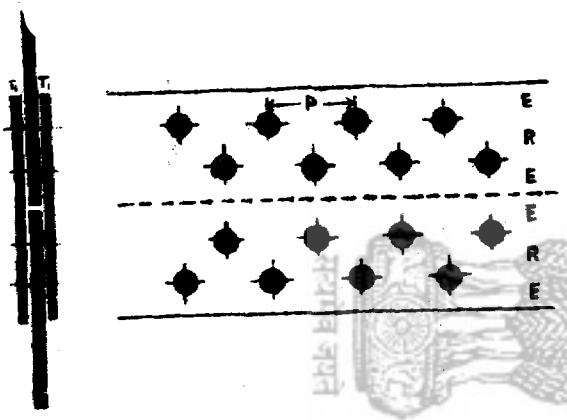
$$R = {\cdot}33\,P + {\cdot}67\,D$$

or $2 \times D$ whichever is greater.

$$E = 1{\cdot}5 \times D$$

$$\text{BUTT STRAP} = 1{\cdot}125\,T \times \frac{(P-D)}{(P-2\,D)}$$

FIG. **10.** DOUBLE BUTT STRAP. TWO RIVETS PER PITCH.



Max. Pitch $= 3{\cdot}5 \times T + 1{\cdot}625$

Plate % $= \dfrac{100\ (P - D)}{P}$

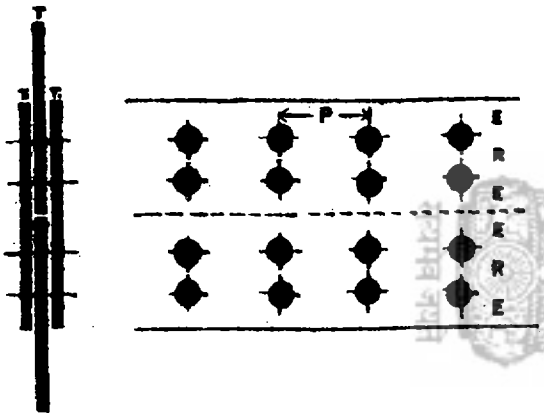
Rivet % $= \dfrac{100 \times A \times 2 \times 1{\cdot}875 \times S_1}{P \times T \times S}$

R $= {\cdot}33\ P + {\cdot}67\ D$

E $= 1{\cdot}5 \times D$

BUTT STRAPS $= {\cdot}625 \times T$

FIG. 11. DOUBLE BUTT STRAPS. TWO RIVETS PER PITCH.



$$\text{Max. Pitch} = 3{\cdot}5 \times T + 1{\cdot}625$$

$$\text{Plate \%} = \frac{100\,(P-D)}{P}$$

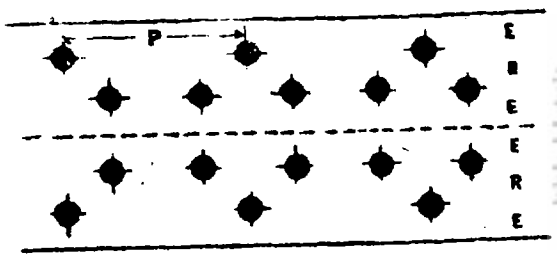
$$\text{Rivet \%} = \frac{100 \times A \times 2 \times 1{\cdot}875 \times S_1}{P \times T \times S}$$

$$R = 2 \times D$$

$$E = 1{\cdot}5 \times D$$

$$\text{Butt Straps} = {\cdot}625 \times T$$

FIG. 12. DOUBLE BUTT STRAP. THREE RIVETS PER PITCH.



$$\text{Max. Pitch} = 4{\cdot}63 \times T + 1{\cdot}625.$$

$$\text{Plate \%} = \frac{100\,(P-D)}{P}$$

$$\text{Rivet \%} = \frac{100 \times A \times 3 \times 1{\cdot}875 \times S_1}{P \times T \times S}$$

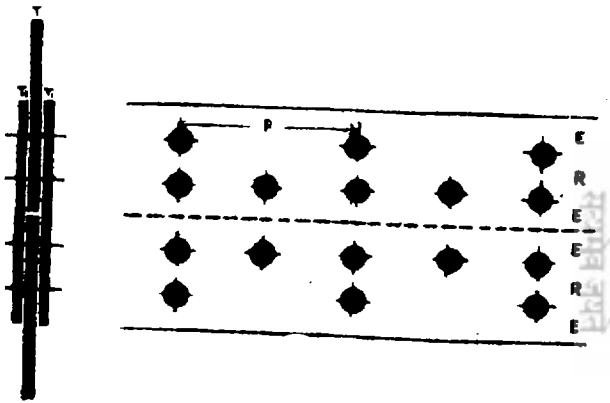
$$\text{Combined \%} = \frac{100\,(P-2\,D)}{P} + \frac{100 \times A \times 1{\cdot}875 \times}{P \times T \times S}$$

$$R = {\cdot}2\,P + 1{\cdot}15\,D$$

$$E = 1{\cdot}5 \times D$$

$$\text{BUTT STRAPS} = {\cdot}625\,T \times \frac{(P-D)}{(P-2\,D)}$$

FIG. **13.** DOUBLE BUTT STRAP. THREE RIVETS PER PITCH.



$$\text{Max. Pitch} = 4{\cdot}63 \times T + 1{\cdot}625$$

$$\text{Plate \%} = \frac{100\,(P-D)}{P}$$

$$\text{Rivet \%} = \frac{100 \times A \times 3 \times 1{\cdot}875 \times S_1}{P \times T \times S}$$

$$\text{Combined \%} = \frac{100\,(P-2\,D)}{P} + \frac{100 \times A \times 1{\cdot}875 \times S_1}{P \times T \times S}$$

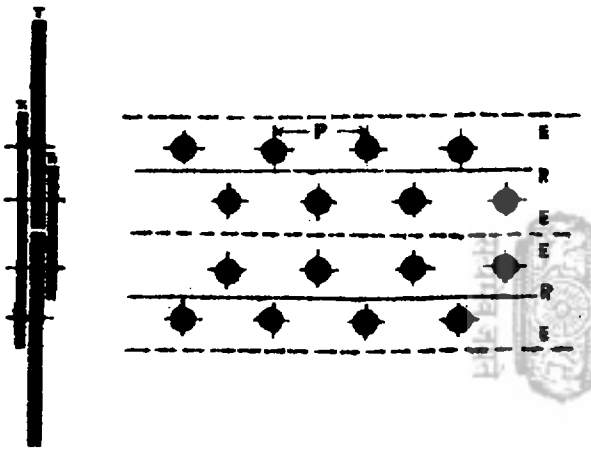
$$R = {\cdot}33\,P + {\cdot}67\,D$$

or $2 \times D$ whichever is greater.

$$E = 1{\cdot}5 \times D$$

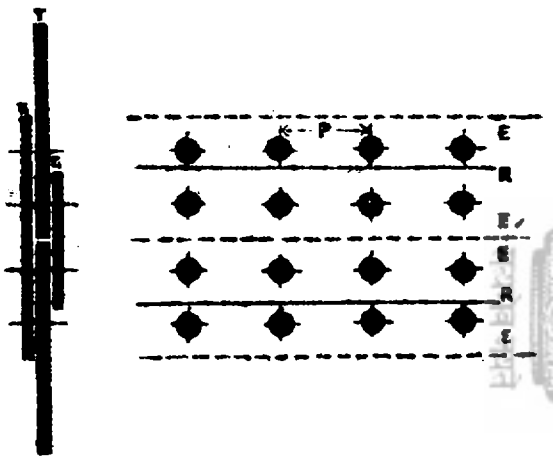
$$\text{BUTT STRAPS} = {\cdot}625\,T + \frac{(P-D)}{(P-2\,D)}$$

FIG. 14. DOUBLE BUTT STRAPS OF UNEQUAL WIDTH. TWO RIVETS PER PITCH.



Max. Pitch	=	$3{\cdot}5 \times T + 1{\cdot}625$
Plate %	=	$\frac{100\ (P-D)}{P}$
Rivet %	=	$\frac{100 \times A \times 2{\cdot}875 \times S_1}{P \times T \times S}$
R	=	$\cdot 33\,P + \cdot 67\,D$
E	=	$1{\cdot}5 \times D$
BUTT STRAP (WIDE.)	=	$\cdot 75\,T$
BUTT STRAP (NARROW.)	=	$\cdot 625\,T$

FIG. 15. DOUBLE BUTT STRAPS OF UNEQUAL WIDTH. TWO RIVETS PER PITCH.



Max. Pitch $= 3{\cdot}5 \times T + 1{\cdot}625$

Plate $\% = \dfrac{100\,(P - D)}{P}$

Rivet $\% = \dfrac{100 \times A \times 2{\cdot}875 \times S_1}{P \times T \times S}$

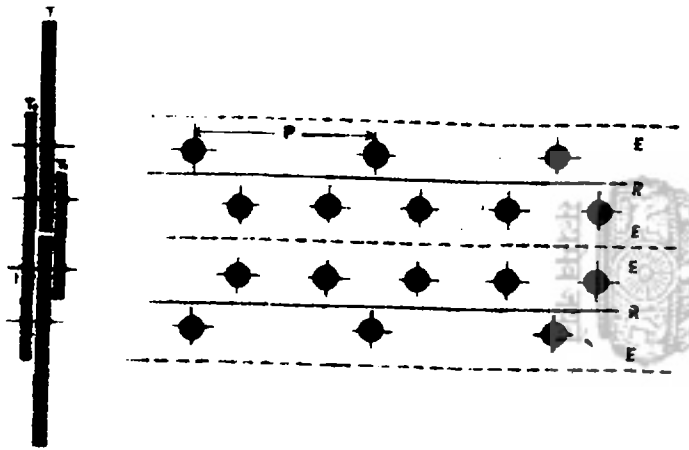
$R = 2 \times D$

$E = 1{\cdot}5 \times D$

BUTT STRAP (WIDE) $= {\cdot}75\ T$

BUTT STRAP (NARROW) $= {\cdot}625\ T$

FIG. 16. DOUBLE BUTT STRAPS OF UNEQUAL WIDTH. THREE RIVETS PER PITCH.



Max. Pitch $= 4{\cdot}63 \times T + 1{\cdot}625$

Plate % $= \dfrac{100\ (P-D)}{P}$

Rivet % $= \dfrac{100 \times A \times 4{\cdot}75 \times S_1}{P \times T \times S}$

Combined % $= \dfrac{100\ (P - 2\ D)}{P} + \dfrac{100 \times A \times S_1}{P \times T \times S}$

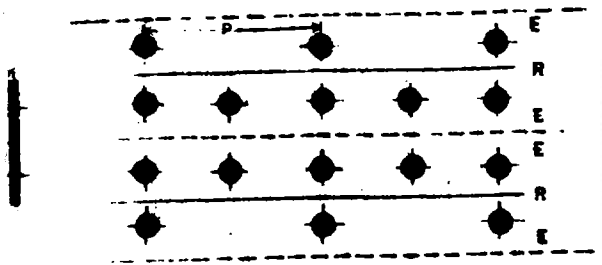
R $= {\cdot}2\ P + 1{\cdot}15\ D$

E $= 1{\cdot}5 \times D$

BUTT STRAP (WIDE) $= {\cdot}75\ T \times \dfrac{(P - D)}{(P - 2\ D)}$

BUTT STRAP (NARROW) $= {\cdot}625\ T \times \dfrac{(P - D)}{(P - 2\ D)}$

FIG. 17. DOUBLE BUTT STRAPS OF UNEQUAL WIDTH. THREE RIVETS PER PITCH.

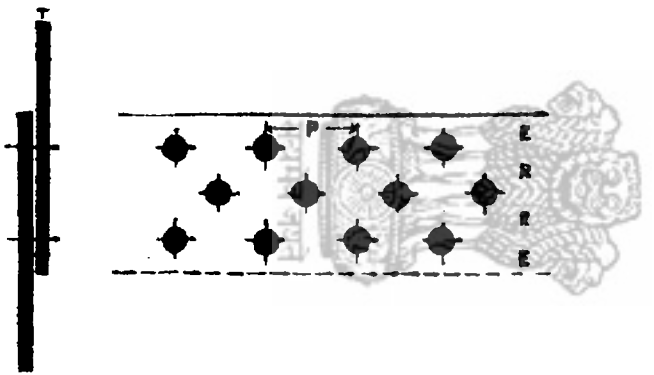


Max. Pitch	$= 4{\cdot}63 \times T + 1{\cdot}625$
Plate %	$= \frac{100\ (P - D)}{P}$
Rivet %	$= \frac{100 \times A \times 4{\cdot}75 \times S_1}{P \times T \times S}$
Combined %	$= \frac{100\ (P - 2\ D)}{P} + \frac{100 \times A \times S_1}{P \times T \times S}$
R	$= {\cdot}33\ P + {\cdot}67\ D$ or $2\ D$ whichever is greater.
E	$= 1{\cdot}5 \times D$
BUTT STRAP (WIDE).	$= {\cdot}75\ T \times \frac{(P - D)}{(P - 2\ D)}$
BUTT STRAP (NARROW).	$= {\cdot}625\ T \times \frac{(P - D)}{(P - 2\ D)}$

TREBLE RIVETED JOINTS.

FIG. 18.

LAP JOINT. THREE RIVETS PER PITCH.



$$\text{Max. Pitch} = 3{\cdot}47 \times T + 1{\cdot}625$$

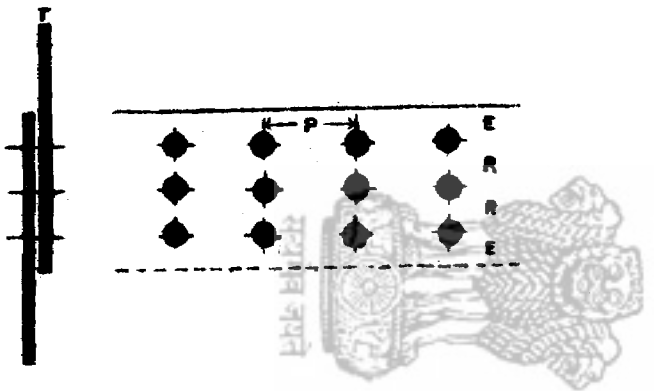
$$\text{Plate } \% = \frac{100\,(P - D)}{P}$$

$$\text{Rivet } \% = \frac{100 \times A \times 3 \times S_1}{P \times T \times S}$$

$$R = {\cdot}33\,P + {\cdot}67\,D$$

$$E = 1{\cdot}5 \times D$$

FIG. **19.** LAP JOINT. THREE RIVETS PER PITCH.



Max. Pitch $= 3{\cdot}47 \times T + 1{\cdot}625$

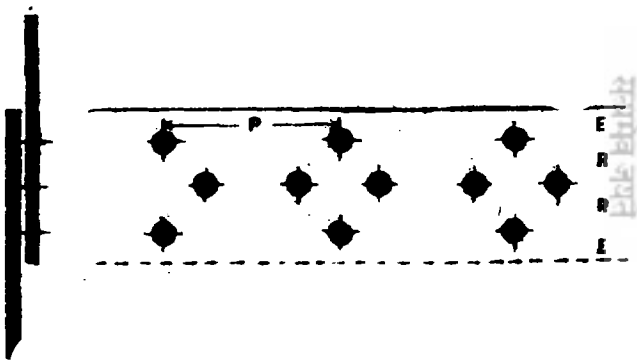
Plate % $= \dfrac{100\ (P - D)}{P}$

Rivet % $= \dfrac{100 \times A \times 3 \times S_1}{P \times T \times S}$

R $= 2 \times D$

E $= 1{\cdot}5 \times D$

FIG. 20. LAP JOINT. FOUR RIVETS PER PITCH.



Max. Pitch $= 4{\cdot}14 \times T + 1{\cdot}625$

Plate % $= \dfrac{100\ (P - D)}{P}$

Rivet % $= \dfrac{100 \times A \times 4 \times S_1}{P \times T \times S}$

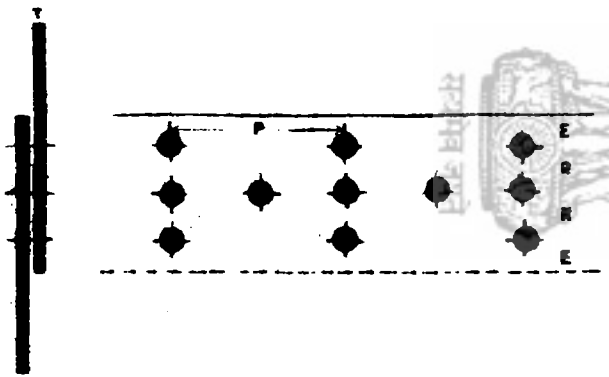
Combined % $= \dfrac{100\ (P - 2\ D)}{P} + \dfrac{100 \times A \times S_1}{P \times T \times S}$

$R = {\cdot}2\ P + 1{\cdot}15\ D$

$E = 1{\cdot}5 \times D$

FIG. 21.

LAP JOINT. FOUR RIVETS PER PITCH.



Max. Pitch = $4{\cdot}14 \times T + 1{\cdot}625$

Plate % = $\frac{100\ (P-D)}{P}$

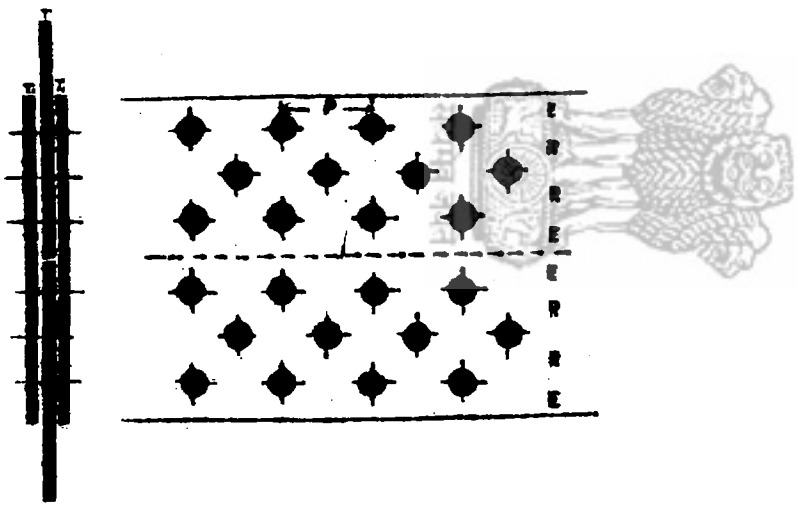
Rivet % = $\frac{100 \times A \times 4 \times S_1}{P \times T \times S}$

Combined % = $\frac{100\ (P-2\ D)}{P} + \frac{100 \times A \times S_1}{P \times T \times S}$

R = ·33 P + ·67 D or 2 D whichever is greater.

E = $1{\cdot}5 \times D$

FIG. 22. DOUBLE BUTT STRAP. THREE RIVETS PER PITCH.



$$\text{Max. Pitch} = 4{\cdot}63 \times T + 1{\cdot}65$$

$$\text{Plate } \% = \frac{100\,(P-D)}{P}$$

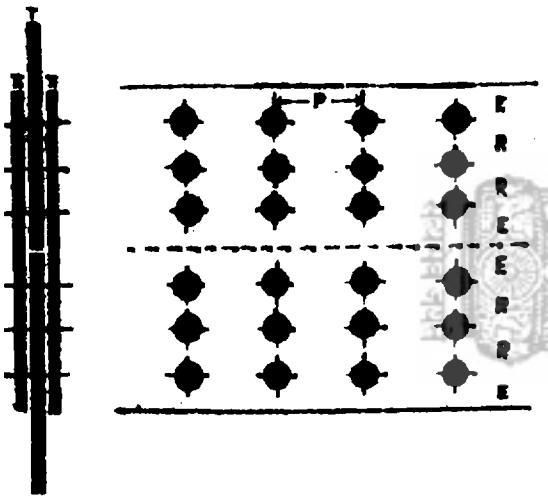
$$\text{Rivet } \% = \frac{100 \times A \times {\cdot}3 \times 1{\cdot}875 \times S_1}{P \times T \times S}$$

$$R = {\cdot}33\,P + {\cdot}67\,D$$

$$E = 1{\cdot}5 \times D$$

$$\text{BUTT STRAPS} = {\cdot}625\,T$$

FIG. 23. DOUBLE BUTT STRAP. THREE RIVETS PER PITCH.



$$\text{Max. Pitch} = 4{\cdot}63 \times T + 1{\cdot}625$$

$$\text{Plate \%} = \frac{100\,(P-D)}{P}$$

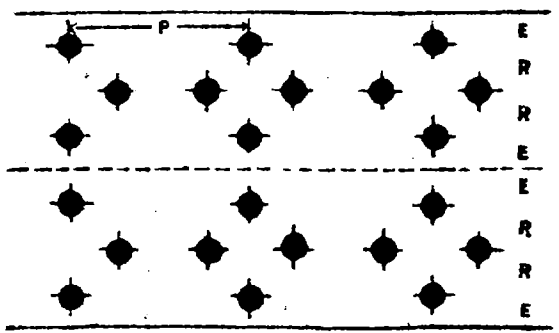
$$\text{Rivet \%} = \frac{100 \times A \times 3 \times 1{\cdot}875 \times S_1}{P \times T \times S}$$

$$R = 2 \times D$$

$$E = 1{\cdot}5 \times D$$

$$\text{BUTT STRAPS} = {\cdot}625\ T$$

FIG. 24. DOUBLE BUTT STRAP. FOUR RIVETS PER PITCH.



Max. Pitch $= 5{\cdot}52 \times T + 1{\cdot}625$

Plate % $= \dfrac{100\ (P - D)}{P}$

Rivet % $= \dfrac{100 \times A \times 4 \times 1{\cdot}875 \times S_1}{P \times T \times S}$

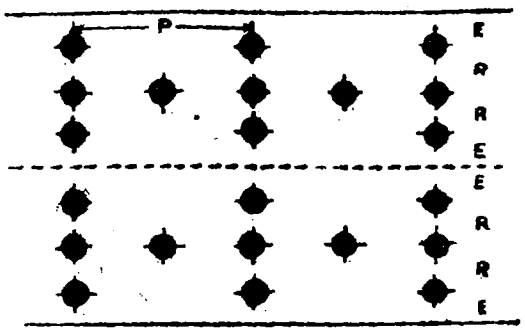
Combined % $= \dfrac{100\ (P - 2\ D)}{P} + \dfrac{100 \times A \times 1{\cdot}875 \times S_1}{P \times T \times S}$

R $= {\cdot}2\ P + 1{\cdot}15\ D$

E $= 1{\cdot}5 \times D$

BUTT STRAPS $= {\cdot}625\ T \times \dfrac{(P - D)}{(P - 2\ D)}$

FIG. 25. DOUBLE BUTT STRAP. FOUR RIVETS PER PITCH.



Max. Pitch $= 5{\cdot}52 \times T + 1{\cdot}625$

Plate $\% = \dfrac{100\,(P - D)}{P}$

Rivet $\% = \dfrac{100 \times A \times 4 \times 1{\cdot}875 \times S_1}{P \times T \times S}$

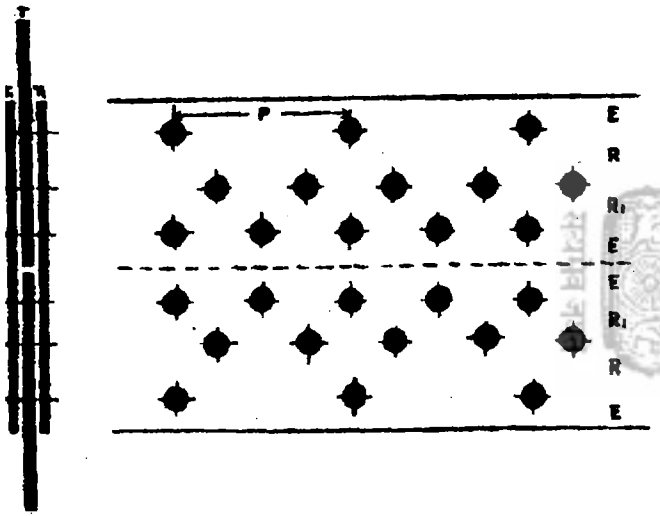
Combined $\% = \dfrac{100\,(P - 2\,D)}{P} + \dfrac{100 \times A \times 1{\cdot}875 \times S_1}{P \times T \times S}$

R $= {\cdot}33\,P + {\cdot}67\,D$ or $2\,D$ whichever is greater.

E $= 1{\cdot}5 \times D$

BUTT STRAPS $= {\cdot}625\,T \times \dfrac{(P - D)}{(P - 2\,D)}$

FIG. 26. DOUBLE BUTT STRAP. FIVE RIVETS PER PITCH.



$$\text{Max. Pitch} = 6 \times T + 1{\cdot}625$$

$$\text{Plate \%} = \frac{100\,(P-D)}{P}$$

$$\text{Rivet \%} = \frac{100 \times A \times 5 \times 1{\cdot}875 \times S_1}{P \times T \times S}$$

$$\text{Combined \%} = \frac{100\,(P-2\,D)}{P} + \frac{100 \times A \times 1{\cdot}875 \times S_1}{P \times T \times S}$$

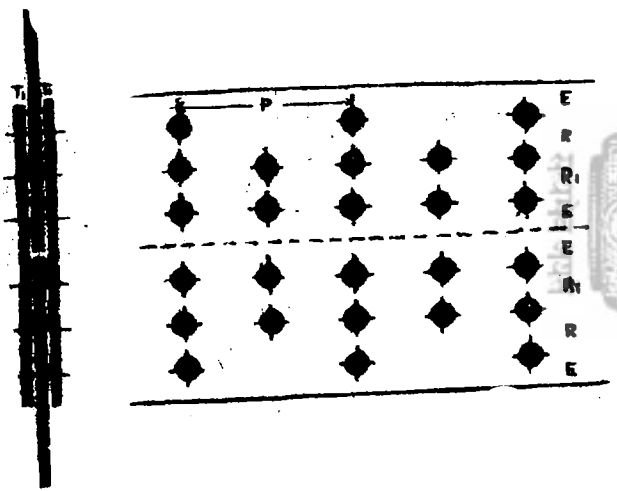
$$R = {\cdot}2\,P + 1{\cdot}15\,D$$

$$R_1 = {\cdot}165\,P + {\cdot}67\,D$$

$$E = 1{\cdot}5 \times D$$

$$\text{BUTT STRAPS} = {\cdot}625\,T \times \frac{(P-D)}{(P-2\,D)}$$

Fig. 27. DOUBLE BUTT STRAP. FIVE RIVETS PER PITCH.



$$\text{Max. Pitch} = 6 \times T + 1{\cdot}625$$

$$\text{Plate \%} = \frac{100\,(P - D)}{P}$$

$$\text{Rivet \%} = \frac{100 \times A \times 5 \times 1{\cdot}875 \times S_1}{P \times T \times S}$$

$$\text{Combined \%} = \frac{100\,(P - 2\,D)}{P} + \frac{100 \times A \times 1{\cdot}875 \times S_1}{P \times T \times S}$$

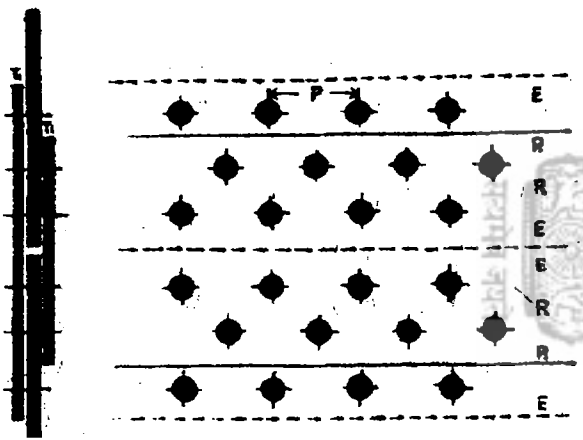
$$R = {\cdot}33\,P + {\cdot}67\,D \text{ or } 2\,D \text{ whichever is greater.}$$

$$R_1 = 2 \times D$$

$$E = 1{\cdot}5 \times D$$

$$\text{Butt Straps} = {\cdot}625\,T \times \frac{(P - D)}{(P - 2\,D)}$$

FIG. 28. DOUBLE BUTT STRAPS OF UNEQUAL WIDTH. THREE RIVETS PER PITCH.



Max. Pitch = $4{\cdot}63 \times T + 1{\cdot}625$

Plate % = $\frac{100\ (P-D)}{P}$

Rivet % = $\frac{100 \times A \times 4{\cdot}75 \times S_1}{P \times T \times S}$

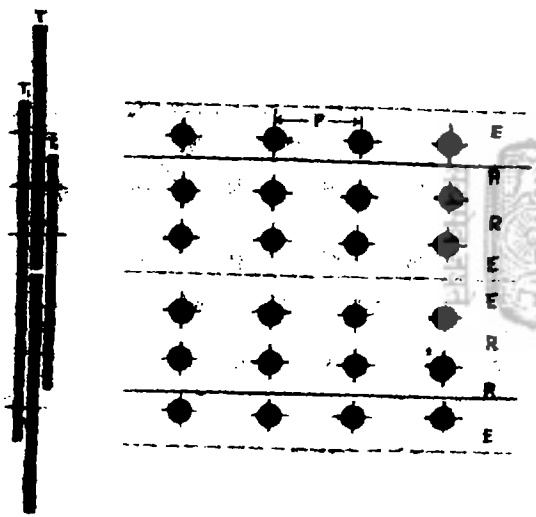
R = $\cdot 33\ P + \cdot 67\ D$

E = $1{\cdot}5 \times D$

BUTT STRAPS (WIDE) = $\cdot 75\ T$

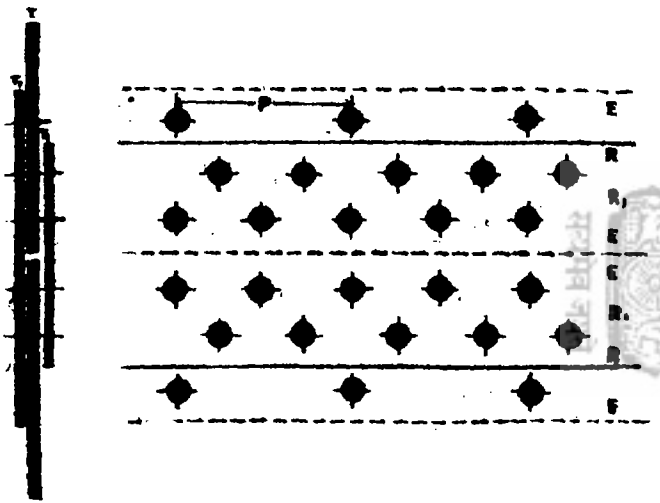
BUTT STRAPS (NARROW) = $\cdot 625\ T$

FIG. 29. DOUBLE BUTT STRAPS OF UNEQUAL WIDTH. THREE RIVETS PER PITCH.



Max. Pitch	=	$4{\cdot}63 \times T \times 1{\cdot}625$
Plate %	=	$\frac{100\ (P-D)}{P}$
Rivet %	=	$\frac{100 \times A \times 4{\cdot}75 \times S_1}{P \times T \times S}$
R	=	$2 \times D$
E	=	$1{\cdot}5 \times D$
BUTT STRAPS (WIDE).	=	$\cdot 75\ T$
BUTT STRAPS (NARROW).	=	$\cdot 625\ T$

FIG. 30. DOUBLE BUTT STRAPS OF UNEQUAL WIDTH. FIVE RIVETS PER PITCH.



$$\text{Max. Pitch} = 6 \times T + 1{\cdot}625$$

$$\text{Plate \%} = \frac{100\,(P-D)}{P}$$

$$\text{Rivet \%} = \frac{100 \times A \times 8{\cdot}5 \times S_1}{P \times T \times S}$$

$$\text{Combined \%} = \frac{100\,(P-2\,D)}{P} + \frac{100 \times A \times S_1}{P \times T \times S}$$

$$R = {\cdot}2\,P + 1{\cdot}15\,D$$

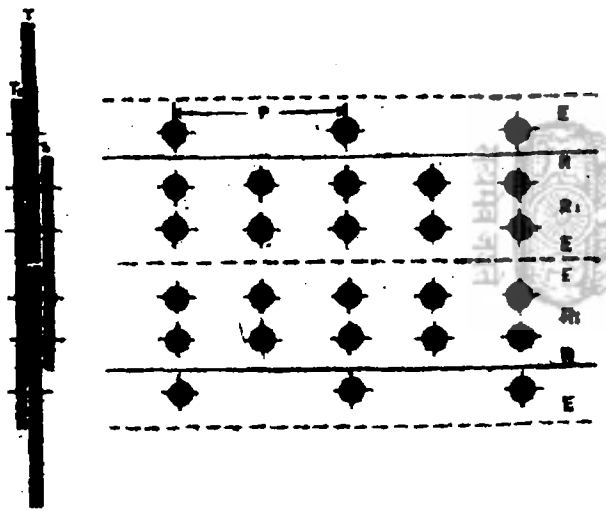
$$R_1 = {\cdot}165\,P + {\cdot}67\,D$$

$$E = 1{\cdot}5 \times D$$

$$\text{Butt Straps (wide)} = {\cdot}75\,T \times \frac{(P-D}{(P-2\,D)}$$

$$\text{Butt Straps (narrow)} = {\cdot}625\,T \times \frac{(P-D)}{(P-2\,D)}$$

FIG. 31. DOUBLE BUTT STRAPS OF UNEQUAL WIDTH. FIVE RIVETS PER PITCH.



Max. Pitch $= 6 \times T + 1{\cdot}625$

Plate $\% = \dfrac{100\,(P - D)}{P}$

Rivet $\% = \dfrac{100 \times A \times 8{\cdot}5 \times S_1}{P \times T \times S}$

Combined $\% = \dfrac{100\,(P - 2\,D)}{P} + \dfrac{100 \times A \times S_1}{P \times T \times S}$

$R = {\cdot}33\,P + {\cdot}67\,D$ or $2\,D$ whichever is greater.

$R_1 = 2 \times D$

$E = 1{\cdot}5 \times D$

BUTT STRAPS (WIDE). $= {\cdot}75\,T \times \dfrac{(P - D)}{(P - 2\,D)}$

BUTT STRAPS (NARROW). $= {\cdot}625\,T \times \dfrac{(P - D)}{(P - 2\,D)}$

Part II.—Inspection.

SECTION I.—REGULATIONS FOR THE REGISTRATION AND INSPECTION OF BOILERS.

1. *Duties of Inspectors.*—Inspectors are required by the Act to measure and examine boilers for registration, examine boilers for renewal certificates, determine, subject to the approval of the Chief Inspector, the pressures at which they are to be allowed to work, grant certificates therefor, and generally convey to the owners such orders as the Chief Inspector may issue. See Section 8 of the Act.

2. *Preparation for Inspection (prescribed under Section 10 (2) (b) of the Act).*—At every inspection of a boiler for the grant or renewal of a certificate the boiler shall be empty and thoroughly clean in all its parts, all doors of manholes, handholes and sightholes and cleaning plugs and all caps in the headers and mud drums of watertube boilers, all firebars, bearers, front plates, bridgeplates, fire bridges, brick arches, oil fuel burners and mechanical stoker fittings shall be removed. All valves and cocks comprising the boiler mountings must be opened up and taken apart and the valves or cocks ground when necessary, before the Inspector's visit.

Provision should be made for the removal of lagging or brickwork or other concealing part and for the drilling of plates, if required by the Inspector, and for verifying the pressure gauge and safety valve dimensions and weights.

All smoke tubes, smoke-boxes, and external flues must be swept clean.

Provision must be made for the effective disconnection of all steam and hot water communication with any other boiler under steam. This must be effected either by the removal of a length of pipe from the steam, feed and blow down piping or by the insertion of substantial blank flanges. Where blank flanges are employed, they must be inserted between the flange of the chest and the pipe attached to it. No blank flange shall be inserted between a safety valve chest and the boiler. It is recommended that blow down water pipes should be separate for each boiler and not connected to one common pipe. Those provisions as to effective disconnection shall extend to every case wherein a person is sent or with the assent of the owner or person in charge goes, into a boiler for any purpose. *Vide* section 27 *(g)* of the Act.

3. *Preparation for hydraulic test (prescribed under Section 10 (2) (b) of the Act).*—The chests of all mountings subject to steam pressure should be in place and shut tight or blank flanged. The safety valves should either be jammed down or removed and the chest-opening blank flanged. The attachment for the Inspector's pressure gauge and the nipple, when provided, for connecting the Inspector's test pump hose should be in order. All doors should be properly jointed and tightened up. The boiler should be completely filled with water, care being taken to allow all air to escape and, if possible, a preliminary test not exceeding the working pressure of the boiler should be taken before the Inspector's visit to test the tightness of the joints.

4. *Measurement of Heating Surface.*—The area of the heating surface of a boiler regulates the area of the safety valves and the amount of the inspection fees. The heating surface for these purposes may be defined generally as the total surface of all plates and tubes exposed to heat on one side and in contact with water on the other, measured on the water side. For Lancashire and Cornish boilers the total heating surface shall include the wetted surface of the furnaces between the end plates and of cross tubes, where fitted, and the part of the external shell below the side flue covers. In estimating the areas, furnaces may be considered as plain cylinders; the area of their wetted surface is to be taken as their mean external circumference × the length of the boiler between end plates. For the shell the width of that part of the circumference below the flue covers is to be taken as $=2$ D, and this width × the length between end plates is to be taken as the area of shell heating surface. The part of the surface of the back end plate exposed to heat is to be neglected.

The formula for the total heating surface of a Lancashire boiler having plain furnaces without cross tubes is therefore: H. S. in square feet$=2L\ (3{\cdot}14d-D)$. L

is the length of the boiler between end-plates in feet d is the mean external diameter of the largest belt of shell in feet.

For steam and water drums of water tube boilers the wetted part of the drum circumference is to be taken as=2D. The length L as the clear length of drum between the outer brick walls. The surface of the tubes is to be taken as the internal wetted surface of each tube between headers or tube plates. The heating surface of the headers is to be neglected.

For marine type boilers the heating surface shall include the wetted surface of the furnaces between the tube plates (considered in the same way as for Lancashire boilers) the wetted surface of the combustion chambers (less the area of the tube holes) and the wetted surface of the tubes between tube plates. The parts of the front tube plate exposed to heat are to be neglected.

For locomotive type boilers the heating surface shall include the wetted surface of the fire-box above the foundation ring (less the area of the tubes and the firehole and ring) and the wetted surface of the tubes between tube plates. The smoke box tube plate is to be neglected.

For vertical boilers of ordinary type the heating surface shall include the wetted surface of the fire-box above the foundation ring (less the area of fire-hole and ring and tube holes, if any) and the wetted surface of any cross or other tubes and uptake below the lowest water level shown in the gauge glass. For any other heating surface not provided for in the foregoing instructions the same general procedure should be observed. No deduction should be made for stays, etc., in calculating the heating surface.

5. *Boiler Rating and Registration Fee (vide Section 27 (d) and Section 8 (1) of the Act).*—The boiler rating to be entered in the certificate shall be the number of square feet, (to the nearest whole figure) in the heating surface of the boiler as determined under clause 4 of this Section.

The fee for the registration of each boiler shall be :—

								Rs.
for Boiler Rating not exceeding							100	40
"	"	"	exceeding	100	but not exceeding		300	50
"	"	"	"	300	"	"	500	60
"	"	"	"	500	"	"	700	70
"	"	"	"	700	"	"	900	80
"	"	"	"	900	"	"	1100	90
"	"	"	"	1100				100

The registration fee shall cover the thorough inspection, hydraulic test, verification of registry number and steam test, subject to the provisions of Section 10 (3) of the Act. In cases where the boiler has not been properly prepared, the Chief Inspector shall have the power to remit the whole or part of the additional fees required under the above Section.

6. *Procedure for Registration.*—On receipt of an application for registration under Section 8 (1) of the Act the Inspector shall, when the boiler has been properly prepared for inspection, proceed to measure in complete detail all its parts, ascertain the working pressure allowed by the Regulations by making a a series of calculations of the strength of the various parts, such calculations being based on his measurements and on the dimensions and other particulars relating to the material and construction stated in the maker's certificate, if satisfied with their correctness (*vide* section 10 (2) (*c*) of the Act and Part I, Section I, clause 1 of the Regulations). In making his calculations he shall after careful examination of the material, take due account of the workmanship and details of construction of each part. In his examination the Inspector may, if he deems necessary, bore the plates or other parts to ascertain their thickness, and in making his calculations he shall be guided by the requirements of sections I, II and III of Part I of the Regulations.

If no formula or co-efficient, applicable to any part, be contained in Part 1, Section III of the Regulations, the Chief Inspector shall, in his discretion, determine the fitness of such part.

The strength of the weakest part so calculated or determined, subject to any discretionary power exercised by the Chief Inspector, shall determine the permissible working pressure of the boiler. After carefully inspecting the boiler and ascertaining by the prescribed calculations the maximum pressure at which the boiler may be worked, the Inspector shall hydraulically test it in accordance with the requirements of clause 12 of this section and may issue a provisional order under section 12 (1) of the Act. The above particulars and dimensions of the boiler and calculations of strength of the various parts together with details of the hydraulic test shall be entered by the Inspector in a "Memorandum of Inspection" book (*vide* clause 8 of this section) which together with all the maker's papers for the boiler shall be submitted to the Chief Inspector for approval of pressure before the issue of an original certificate under section 8 (3) (*a*) and (4) of the Act.

On completion of the first thorough inspection, measurement and hydraulic test of the boiler the Chief Inspector shall, if satisfied with the result, allot a Registry number under Section 8 (3) (*b*) and issue his orders under section 8 (3) of the Act, but the registration and examination under section 8 of the Act shall not be complete until the engraving of the Registry number of the boiler under section 8 (4) of the Act has been verified by the Inspector.

7. *Engraving of Registry number (prescribed under Sections 8 (4) and 27 (d) of the Act).*—The registry number of every boiler shall be cut in the front plate thereof in such position as shall be pointed out by the Inspector. The device for each Province shall be distinguished by the following letters :—

Bihar and Orissa	B. O.
Bengal	B. L.
Bombay	B. Y.
Burma	B. A.
Central Provinces	C. P.
Madras	M.
Punjab	P. B.
United Provinces	U. P.

The distinguishing letter shall be engraved above the number and separated therefrom by an horizontal line 2½ inches in length. The letters and figures shall be 1 inch in height and of corresponding breadth and thickness.

The whole shall be enclosed in a rectangle the upper and lower sides of which shall be 3 inches apart and one quarter of an inch clear of the top of the letters and bottom of the figures respectively, as indicated below. The side lines shall be an equal distance clear from the figures.

The engraving shall be not less than one sixty-fourth of an inch in depth. In the case of small boilers the letters and figures of the device may, in the discretion of the Chief Inspector, be reduced to three-eighths of an inch in height.

Engraving slips for tracing the device on the boiler will be supplied by the Chief Inspector. The slip should be pasted on the part of the boiler pointed out by the Inspector and the engraving shall be complete and ready for verification within 30 days of the date of the first inspection of the boiler.

Boilers having registry devices differing from those prescribed herein shall, on these Regulations coming into force, have such devices obliterated, altered or cut anew in conformity with those prescribed above. The original numbers of such boilers shall be retained in the new device. A number once allotted to a boiler shall not be used again for another boiler.

8. *Memorandum of Inspection Books (prescribed under section 8 (2) of the Act.)*—A memorandum of inspection book shall be prepared for each boiler in Form I. In it the Inspector shall enter in ink all particulars and dimensions of the boiler with the calculations for the various parts in detail, particulars of hydraulic test and steam test and his inspection notes. At subsequent inspections Inspectors shall enter the dates of inspections, hydraulic tests and steam tests when such are made, with their notes thereon, particularly noting to what extent boilers have been cleared of brickwork, etc., the general condition of the boiler and repairs. They should also note all casual visits, inspections of main steam pipes, visits for inspection of repairs or enquiry into accidents and so provide a useful record of the boiler's history for the information and guidance of Inspectors at subsequent inspection.

Inspectors shall, as soon as convenient after an inspection, make the necessary entries in the Memorandum of Inspection books; care being taken to preserve and keep the books clean, and afterwards submit them to the Chief Inspector. For newly registered boilers the Chief Inspector shall check all particulars and calculations and shall approve the working pressure that is to be permitted for the boiler. For old boilers he should examine the Inspector's notes of inspection and proposals made for repairs or reduction of pressure under the proviso to Section 11 of the Act. A pressure once approved for a boiler is not to be altered without the written authority of the Chief Inspector. Inspection books except when actually required by the Inspector are to be filed in the office of the Chief Inspector.

9. *Registration Books.*—A registration book containing all the particulars required for registration and notes at subsequent inspections, copied from the Memorandum of Inspection book, shall be maintained in the office of the Chief Inspector in Form I and any orders passed by him regarding the boiler shall be entered in the registration book under his initials.

The Registration Book, on a boiler passing from one part of India to another, shall on the request of the Chief Inspector of the Province to which the boiler has been transferred, be forwarded to that officer who shall take over its custody and maintain it as prescribed above.

10. *Procedure at Subsequent Inspections.*—At subsequent inspections the Inspector should carefully gauge and record the circularity of furnaces of boilers having cylindrical furnaces. A vertical and an horizontal gauging should always be taken of at least the three first furnace rings in Adamson type furnaces and be recorded in the Memorandum of Inspection book. He should sound gusset stays, rivets to detect slack or broken ones and carefully examine gusset angles for fractures. The water sides of the end plates around the shell line, furnace flanges, and at toes of gusset stays and the bends of furnace flanges should be closely examined for grooving. Deep grooving in the bends of the flanged-out furnace mouth of end plates is a common defect when the water is bad and is difficult to detect. Screw stays should be sounded for breakages and smoke tubes that appear thin, should be tested at their ends with a short bar. All internally fitted manhole and other doors should be tried in place to test their fit. All mountings must be examined internally and externally at each inspection. When any part is wasted and the Inspector is doubtful of its fitness for the pressure he should cause one or more small holes to be bored and from them ascertain the average thickness of the parts from which he can satisfy himself by calculation in accordance with the formula applicable to the part. Such gaugings and calculations should be entered in his inspection book. With regard to pitting and wasting of shell plates the Inspector must bear in mind that shell plates may become reduced in thickness to an appreciable extent and still retain a higher percentage of original thickness than the longitudinal seams.

In making his calculations for a wasted part of a boiler shell, *e.g.*, along the line of seating blocks of a Lancashire boiler, the Inspector should use the ordinary shell pressure formula without J, the percentage strength of joint.

When the Inspector decides that a boiler in one or more of its parts is no longer fit for the pressure approved for it, he must, without delay, report his proposals for reducing the pressure to the Chief Inspector and at the same time submit his calculations for the wasted parts for check and approval of pressure.

Generally at a thorough inspection of a boiler the Inspector must, wherever the size permits, go inside it and make a thorough inspection of all its internal parts

Before doing so, however, he should satisfy himself that proper provision has been made for disconnection from any other boiler under steam. Should he find that proper provision for disconnection has not been made or that the boiler has not been properly cleaned or scaled or that it is unreasonably hot he should decline to proceed with the inspection and should report the facts to the Chief Inspector for orders, under Section 10 (3) of the Act.

When a boiler is of such a size or its construction is such that an Inspector cannot go inside it, there must be sufficient sight holes or hand holes provided to enable him to see the principal internal parts and if any important part of a boiler is so constructed that the Inspector cannot examine it, he should report the facts to the Chief Inspector for orders. Boilers must be examined externally as well as internally and particular attention should be paid to the external parts of boilers in way of seating blocks, especially when the situation is damp and, having regard to many serious defects discovered, Inspectors should take care, in order to ensure proper inspection, that boilers the whole of the inside of which cannot be readily examined are cleared whenever they consider it necessary of any concealing, covering, supports or fittings. Saddle tanks and engine fittings of locomotive type boilers should be removed for inspection of the parts underneath at the first inspection and at any reasonable period afterwards if the Inspector cannot satisfy himself. If the owners in any special case have any good reasons for not wishing to clear covered parts, the case should be submitted to the Chief Inspector for orders. The Inspector must however recollect that he is not to certify as efficient any boiler regarding the condition of which he cannot thoroughly satisfy himself.

11. *Entries in Certificates.*—The Inspector should state in his certificate the load to be placed on the safety valves or the thickness of washers or ferrules required as a safeguard against overloading, the date and pressure of the last hydraulic test of the boiler and, when applicable, of the main steam pipes attached to it.

His remarks should be brief. In the absence of remarks on the boiler's condition the boiler will be considered to be in good condition.

In the remarks column he should state his requirements if any, with regard to hydraulic test, removal of lagging, brickwork or other concealing parts for the next inspection, to enable the owner to have the same properly prepared at that time; but omission of requirements from the certificate is not to deter the Inspector from requiring a hydraulic test or further removal of brickwork or concealing parts, if he considers the same necessary for his inspection. He should also state in the same place his requirements regarding the repair or renewal of any part that may be considered fit only for the period of the certificate.

When the Inspector is unable to grant a certificate he should inform the owner according to the provisions laid down in section 11 of the Act.

12. *Hydraulic Tests.*—Every new boiler shall be hydraulically tested in the presence of an Inspector to not less than twice the approved working pressure when such working pressure does not exceed 100 lbs. per square inch. When the approved working pressure is above 100 lbs. per square inch the hydraulic test pressure must be one and a half times the working pressure *plus* 50 lbs. per square inch.

The boiler must satisfactorily withstand without appreciable leakage or undue deflection or distortion of its parts such pressure for at least ten consecutive minutes. If the test is not satisfactory the working pressure allowable by calculation must be suitably reduced, unless the owner is willing to make such alterations as will enable the boiler to withstand satisfactorily the hydraulic test, when after alteration the boiler must be again examined, the pressure recalculated if necessary, and the boiler tested to the satisfaction of the Inspector.

At the first hydraulic test of a boiler prior to the issue of an original certificate careful deflection measurements must be made before, during, and after test of each furnace length, firebox and flat end or other plates; and such measurements with other details of the test are to be entered in the Memorandum of Inspection book before its submission to the Chief Inspector.

Every boiler at its first hydraulic test must be entirely cleared of lagging or brickwork. At subsequent hydraulic tests the lagging or brickwork or portions thereof must be removed, if required by the Inspector. Generally, his requirements

in this respect for a future test should be entered in the certificate for the boiler.

After the application of the hydraulic test the Inspector shall, before issuing a provisional order or certificate, carefully examine the boiler inside and outside and satisfy himself that it has satisfactorily withstood the test.

In any case in which the safe working pressure to be allowed for a boiler cannot, owing to peculiar construction of any of its parts, be determined by calculation in the ordinary way, the Inspector shall under the direction of the Chief Inspector subject the boiler to hydraulic test for the purpose of determining the fitness of such parts. The amount of the test pressure to be applied in such a case must not exceed the test pressure prescribed for the least working pressure found by calculation for other parts of the boiler or the intended working pressure, whichever is less. Should any part of the boiler show undue deflection or indication of permanent set during the progress of the test, the pressure must be released immediately such indications are observed. The working pressure for the part should be one half of the test pressure applied when the point of permanent set was reached. This procedure shall apply to any boiler at any test.

Hydraulic test of boilers at subsequent inspections shall, except when the Inspector expressly requires otherwise, be made after the inspection. The test pressure to be applied to old boilers should be from one and a quarter to one and a half times the working pressure of the boiler.

When the internal construction or size of a boiler will not permit of the Inspector getting inside it or of examining closely all its parts, he shall see it tested by hydraulic pressure to one and a half times the working pressure at each certificate inspection.

Water tube, locomotive type and all tubular boilers must be hydraulically tested at each certificate inspection, unless such test is waived under the orders of the Chief Inspector.

The Inspector may at any inspection, if he considers it necessary, apply a hydraulic test to any boiler.

The hydraulic test of all boilers except in the case of small portable and vehicular boilers not requiring re-erection or building in brickwork, shall be conducted only after the erection of the boiler *in situ* and all boilers shall after re-erection in a position different from that in which they last were examined, be hydraulically tested. An hydraulic test shall also be taken before granting an increased pressure certificate and after repairing a boiler, unless the Chief Inspector authorises the Inspector to waive such test.

When carrying out hydraulic tests Inspectors are to use the pressure gauges supplied by the Department.

13. *Steam Tests.*—Every newly registered boiler and every other boiler of which the working pressure has been altered shall, before the issue of an original or renewal certificate for such boiler, be tested under steam to the satisfaction of the Inspector.

Due notice of the date fixed for the steam test shall be sent to the owner by the Inspector.

Preparation for Steam Test.—A steam test is primarily intended for the purpose of ascertaining by actual test whether the safety valves are sufficient to relieve the boiler effectively of excess steam, and whether they operate at the time the maximum working pressure is reached. At the time of test the safety valves should be left free and capable of being adjusted to the approved working pressure.

After adjustment of the valves to the correct blowing pressure the boiler should be tried under full steam and firing for at least fifteen minutes with the feed water shut off and the stop valve closed, during which time the Inspector should note the accumulation of pressure and other details of the test as well as the loading and adjustment of the safety valves.

On completion of the safety valve test the Inspector should satisfy himself that the water gauges are in working order and that the feed apparatus is capable of supplying the boiler with sufficient water. He may also when he thinks fit satisfy himself by questioning or practical test whether the person-in-charge of the boiler

understands the use and purpose of the water gauges, the pressure gauge, the safety valves, the feed water supply and blow down, as it is the Inspector's duty under section 13 of the Act to refuse to recommend a certificate for a boiler unless the attendant is, in his opinion, competent to have charge of it.

When witnessing safety valve tests Inspectors are to use the standard pressure gauges supplied by the Department, unless the boiler pressure gauge has since the time of Inspection been tested and found correct with the Department's testing machine.

No steam gauge should be used without a syphon filled with water between it and the boiler.

On completion of the test the Inspector shall enter all details in the Memorandum of Inspection Book which shall be submitted to the Chief Inspector for his approval before the issue of a certificate. When the accumulation of pressure at a steam test exceeds ten per cent. of the maximum working pressure, the area of the safety valves must be considered insufficient and a certificate should be refused until the safety valve area is increased.

An Inspector may, when visiting a factory for any purpose, verify the correctness of the safety valves and pressure gauge of any boiler under steam by comparison with his standard pressure gauge.

14. *Repairs to Boilers.*—Extensive repairs such as renewal of furnaces, end plates, parts of shell, fire boxes, girders, etc., should be supervised, so far as his other duties permit, by the Inspector and at such times when fireboxes and smoke tubes of locomotive type boilers are withdrawn, advantage of the opportunity should be taken to inspect the internal parts otherwise inaccessible to close inspection.

The renewed parts should be treated as parts of a new boiler and must comply with the Regulations in force at the time for the intended pressure. Under clause 4 boilers are liable to an hydraulic test after repairs.

15. *Submission of Plans of Boilers.*—In the case of land boilers made in India or outside India for use in British India the Chief Inspector may, on receipt of a Treasury acknowledgment of the prescribed fee, receive for examination plans and particulars of materials, design and construction of boilers before hand so as to avoid questions arising at the examination of the finished boilers.

The Chief Inspector shall after examination of the plans and particulars furnish the proposers with his opinion as to whether he is satisfied with the design and fitness of the parts for the intended pressure or, if not, what modification may be necessary therein. When plans and particulars of boilers have been approved, the Inspector in making his examination shall see that the designs as approved have been carefully followed out and that the material corresponds with the approved particulars.

The above procedure should be followed in the case of extensive repairs or alterations to boilers, but no fee will be charged for the examination of such plans and particulars.

SECTION II.– STEAM PIPES.

1. *Inspection of Steam Pipes, [prescribed under section 27 (e) and (f) of the Act]*—Steam pipes should be inspected and hydraulically tested before erection in place, the test pressure to be that prescribed in the Standard Conditions for steam pipes. If the Inspector is satisfied with the test the pipes may be erected in position and at the steam test of the boiler he should examine them under steam pressure. No separate certificate for the steam pipes is to be issued, nor is a separate fee to be charged for their inspection. At subsequent inspections of the boiler or at any other time, the Inspector may make an external inspection of the steam pipes and for this purpose may require the whole or part of the lagging to be removed, but usually it will be sufficient if a part of the lagging at the flanges, as pointed out by the Inspector, is removed and the pipe made bare. The pipes shall be hydraulically tested, in place if practicable, every five years, dating from the first hydraulic test and at such test the pipes shall be bared of all covering and the Inspector shall make a close external inspection of them. The test pressure at such hydraulic tests shall be not less than twice the working pressure of the boiler.

The date and hydraulic pressure to which steam pipes were subjected shall be entered in the certificate for the boiler and such entries shall be continued from time to time in the renewal certificates for the boiler.

Inspectors shall see that steam pipes are fitted with suitable means of drainage. Pockets or low-lying bends, in which condensed steam is likely to collect, should not be permitted.

Efficient means for draining steam pipes should be provided in every case. Boiler stop valves cannot be regarded as suitable for this purpose. All drain cocks or valves shall be accessible and be so placed as to render it practicable to drain the water from any part of the steam pipes or chests connected with them. Drain pipes should be fitted to drain cocks or valves when the latter are in such a position that the water or steam discharged from them would be likely to cause personal injury.

It is desirable that the drains should be automatic in their action.

Suitable provision should be made for expansion either by means of large bends or, in the case of long lengths of straight pipes, by expansion joints. The Inspector must see that expansion joints of socket type are in every case so fitted, that the end of the pipe cannot be forced out by the action of the steam pressure or movement of the pipe.

2. *Material.*—The Chief Inspector is authorised to permit the use of cast iron steam pipes in exceptional circumstances as a temporary measure only for such period and subject to such condition as he may prescribe.

3. *Submission of Plans of Steam Pipes.*—Plans of steam pipes shall be submitted to the Chief Inspector before construction or at the time of registration of the boiler for his opinion whether the pipes and their arrangement will comply with the Regulations.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APPENDIX I-C.

Model Administrative Rules framed under Section 28 of the Indian Boilers Act.

ACT OF 192


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I.—Preliminary.

Definitions.

1. In these rules unless there is anything repugnant in the subject or context,—

(*a*) " The Act " means the Indian Boilers Act of 192

(*b*) " Section " means a section of the said Act.

(*c*) " Regulation " means a regulation framed by the Government of India under Section 27 of the said Act.

Payment of fees.

2. All fees payable under the Act shall be deposited by the payer in a Government Treasury or the Imperial Bank of India. Applications under Sections 8 and 9 of the Act, to which the treasury or bank receipt for payment is affixed, shall be deemed to be accompanied by the prescribed fee.

II.—Duties of the Chief Inspector.

Control by Director of Industries.

3. The Chief Inspector shall work under the administrative control of the Director of Industries, and shall submit to him :—

(*a*) an Annual Report on the administration of the Act ;

(*b*) such other reports and returns as may be called for.

Exceptional cases which are not covered by the regulations or rules should be reported to the Director of Industries.

Duty of general control.

4. The Chief Inspector is vested with all the powers of an Inspector under the Act. His main duty, however, consists in supervising and controlling the work of the Inspectors, and he should only actually inspect or examine boilers in exceptional cases, or where he considers that the work of an Inspector requires a personal check.

Specific duties.

5. The Chief Inspector shall :—

(*a*) personally check the registration and measurements of all newly registered boilers, for the initial working pressure on the basis of Part I of the Regulations and enter under his own signature all orders required by Section 8 ;

(*b*) enter under his own signature any subsequent entries required in the registration book ;

(*c*) obtain from the province of registry the registration book of any boiler the transfer of which is reported under Section 7 (*b*) ;

(*d*) fix the area under the control of each Inspector ;

(*e*) approve the programme of all inspectors subordinate to him with due regard to the convenience of owners generally ;

(*f*) examine and countersign the Inspectors' Memorandum of Inspection Book of each boiler after each inpection ;

(*g*) examine and pass orders on the diaries and returns of inspectors ;

(*h*) pass orders in all cases in which an Inspector proposes to increase or reduce the pressure allowed for any boiler under Section 11, or to revoke, cancel or refuse to renew the certificate of a boiler under Section 13, or to order important repairs, structural alterations, or renewals in a boiler under Section 11 ;

(*i*) pass orders in all cases in which it is reported that after due notice the boiler has not been properly prepared for inspection ;

(*j*) decide all appeals against the order of an Inspector under Section 19 ;

(*k*) sanction prosecutions under the Act ;

(*l*) enquire into serious accidents to boilers.

Instructions to owners.

6. It shall be the duty of the Chief Inspector to advise owners as regards the maintenance, working and cleaning of boilers ; he should issue a set of instructions on the lines indicated in the Appendix. These instructions should be hung up in each boiler house.

Registers to be kept.

7. The Chief Inspector shall keep in his office :—

(*a*) a Register in Form A of all boilers registered in the province, or the registry of which has been transferred from another province.

(*b*) The Registration Book and Memorandum of Inspection Book of all boilers borne on his register.

(*c*) a Register of Appeals.

(*d*) a Register of Accidents.

(*e*) a Register of Registration and Inspection fees received.

Control of bills.

8. The Chief Inspector shall be the controlling or countersigning authority in respect of all contingent bills and of travelling allowance bills of officers subordinate to him.

III.—Duties of Inspectors.

Subordinate to Chief Inspector.

9. Inspectors shall be directly subordinate to and under the control of the Chief Inspector ; they should ordinarily be appointed to take charge of specific areas.

General duties of Inspectors.

10. The main duties of the Inspector, as laid down in the Act, are the inspection and examination of boilers and steam-pipes. Inspections shall be carried out in accordance with Part II of the Regulations and Parts IV and V of these Rules, which must be very closely observed.

Search for unregistered boilers.

11. In addition to the inspection and examination of boilers, it is the duty of Inspectors to search for unregistered or uncertificated boilers within their areas, and to see that certificated boilers are worked in accordance with the terms of their certificates.

Advice to be given to owners.

12. At the time of inspection, Inspectors should advise the owner and the person in charge of the boiler on the management and upkeep of the boiler with special reference to the amount of cleaning required in view of the quality of water used.

Specific duties.

13. Inspectors shall —

(*a*) prepare a programme of inspections with regard to the convenience of owners generally and submit it at such periods as may be prescribed, at least 14 days before the first date fixed in the programme, to the Chief Inspector for approval ;

N. B.—Inspection of boilers in seasonal factories should ordinarily be fixed immediately after the date when work in the factory ceases, and in all cases during the off season.

(*b*) maintain a Memorandum of Inspection Book for each boiler under their charge and submit it to the Chief Inspector for examination and countersignature after each inspection ;

(*c*) keep a diary for weekly submission to the Chief Inspector, showing places visited, boilers registered or inspected with fees paid thereon, variations from the programme and any other important particulars ;

(*d*) receive applications for registration or inspection under Sections 8 or 9, proposals for repairs, alterations or renewals under Section 14 and reports of accidents under Section 17 ;

(*e*) enquire into accidents to boilers or steam-pipes and report to the Chief Inspector ;

(*f*) report to the Chief Inspector cases of unreported accidents discovered at the time of inspection ;

(*g*) submit for the orders of the Chief Inspector :—

(*i*) the Memorandum of Inspection Books of all boilers proposed for registration under Section 8 ;

(*ii*) proposals for increasing or decreasing the pressure of a boiler after inspection under Section 11 ;

(*iii*) proposals for necessary repairs, structural alterations or renewals to a boiler under Sections 11 or 14 ;

(*iv*) proposals for revoking, cancelling or refusing to renew a certificate under Sections 13 or 11 ;

(*v*) report when boilers have not been properly prepared for inspection under Section 10 ;

(*vi*) proposals for prosecutions under the Act.

Inspections at special times.

14. No examination of a boiler shall be made by an Inspector for the purpose of registering or issuing a certificate for a boiler on a Sunday or between the hours of sunset or sunrise without the specific orders of the Chief Inspector in each case. In such cases a double fee may be charged, half of which may be payable to the Inspector.

Attendance during hearing of appeals.

15. Under orders of the Chief Inspector, Inspectors shall attend during the hearing of appeals with regard to boilers under their charge before the Chief Inspector or the Appellate Authority.

Registers to be kept.

16. Every Inspector shall keep in his office :—

(*a*) a Register in Form A of all registered boilers situated within his jurisdiction ;

(*b*) a Register of Accidents ;

(*c*) a Register of Registration and Inspection fees received.

IV.—Administrative Instructions for Registration.

Importance of registration.

17. Technical regulations for the registration of boilers and the scale of fees for registration are prescribed in Part II of the Regulations. The details of measurement recorded at the time of registration constitute a permanent record for the boiler and determine the original pressure at which the boiler is allowed to work. It is accordingly essential that the work should be done with the greatest care and precision.

Receipt of applications.

18. Applications for registration shall be made under section 8 (1) either to the Chief Inspector, or to the Inspector of the local area in which the boiler is situated and shall be accompanied under rule 2 by a receipt for the prescribed fee. No application shall be accepted without the receipt. No boiler shall be registered, if on measurement the fee is found to be deficient, until the deficit has been paid. Any excess payment will be refunded at the time of registration.

19. It is essential that no delay should occur in registration. In large towns, the measurements under Section 8 (2) should ordinarily be completed and the report submitted to the Chief Inspector within 7 days of the receipt of the application; in no cases should the interval exceed 30 days. The Chief Inspector should issue his orders under Section 8 (3) without delay.

Necessity of avoiding delay.

20. The Chief Inspector shall maintain a Register of Registered Boilers in serial order in Form A in two parts; in Part I (Boilers originally registered in the province) the registered number of a boiler shall be the one immediately following the last serial number in the Register. Gap numbers due to boilers being broken up or transferred to another province shall not be filled up. In Part II (Boilers originally registered in other provinces) entries shall be made as prescribed in Rule 22. Inspectors shall keep a similar Register for all boilers within their jurisdiction.

Register of Registered Boilers.

21. Whenever a boiler is transferred from one province to another, the owner shall, under Section 7 (*b*), apply to the Chief Inspector of the province to which the boiler is transferred, for the registration of the transfer; the boiler cannot be used until registration has been effected. The Chief Inspector shall then obtain from that province the Registration Book and Memorandum of Inspection Book of the boiler. No fee shall be charged for recording transfers.

Procedure on transfer of a boiler.

22. On receipt of the Registration, and Memorandum of Inspection Books, the Chief Inspector shall enter the boiler under its original number in Part II of his Register, and shall instruct the Inspector of the local area in which the boiler is situated to enter it similarly in his Register. The Registration Book and the Memorandum of Inspection Book shall be kept in the Chief Inspector's Office.

Entry of transferred boiler in Register.

23. Whenever a boiler has been transferred or broken up, the fact shall be noted in the Register of the Province from which it has been transferred. In the case of a boiler that has been permanently dismantled the Registration Book and the Memorandum of Inspection Book shall be destroyed.

Note of transferred and dismantled boilers.

V.—Administrative Instructions for Inspection.

24. Detailed instructions for the inspection of boilers are contained in Part II of the Regulations. In making inspections it is important that the Inspector should pay particular attention to entries made in the Memorandum of Inspection Book at the time of the previous inspection.

Reference to previous inspections.

25. In arranging for inspections particular attention should be paid to the provisions of rule 13 (a). The notice required by Section 10 shall be sent in Form B. If an hydraulic test is necessary in addition to the ordinary inspection ample notice must be given to the owner. During the inspection of one of a battery of boilers, the Inspector should take the opportunity of examining the other boilers under steam, with special reference to the water gauges, pressure gauge, and safety valves.

Procedure during inspection.

26. In cases in which the Inspector is empowered to issue a certificate under Section 11 without further reference, the certificate should ordinarily be issued within 48 hours of the completion of the inspection. Where he proposes to issue a provisional order, the Inspector must satisfy himself that the boiler is fit to be worked at the maximum pressure and for the period entered in the provisional order. The fact of issue of a provisional order must be reported immediately to the Chief Inspector.

Issue of certificates and provisional orders.

27. Provisional orders and certificates shall be issued in Forms C and D, respectively.

28. Fees for inspection shall be calculated on the basis of boiler rating, as prescribed in part II, Section I, Clause 5 of the Regulations. The following fees are prescribed :—

VI.—Accidents.

Investigation of accidents.

29. On receipt of a report of an accident to a boiler or steam-pipe under Section 17, the Inspector should, with the least possible delay, proceed to the place to investigate the accident. If the report is received by the Chief Inspector, he should forward it at once to the Inspector, within whose jurisdiction the accident has occurred, for necessary action.

Procedure during enquiry.

30. The Inspector at his enquiry shall make a careful examination of the damaged parts, and shall take such measurements and make such sketches for the purpose of his report, as he may deem necessary. He shall enquire into the circumstances attending the accident and note the time of its occurrence, its nature and extent, the injury caused to persons and the damage done to property. The report should be in the style of the Reports of Preliminary Enquiries under the British Boiler Explosion Acts, 1882 and 1890.

Power to hold enquiry in writing.

31. Inspectors are authorized to take the written statements of witnesses and all persons immediately concerned with the accident. In order to comply with the provisions of Section 17 (2), the Inspector should present to the owner or person in charge of the boiler a series of written questions on all points that are material to the enquiry.

Use of boiler after accident.

32. The Inspector must decide whether the use of the boiler can be permitted at the same or at a lower pressure without repairs or pending the completion of any repairs or alterations that he may order. In no case should he issue a provisional order or renewal certificate, until his orders have been carried out.

Procedure in case of serious accidents.

33. The report should be sent without delay to the Chief Inspector; if he considers that the investigation has been sufficient, he will record the facts in his Register of Accidents, and enter a brief account of the accident in the Registration Book, a copy being made in the Memorandum of Inspection Book. If, however, the accident is of a serious nature and in all cases in which an explosion has occurred, the Chief Inspector should after receipt of the Inspector's report, proceed to investigate the accident personally or to move the Local Government to appoint a Commission to enquire into the accident. Reports of such enquiries should be recorded as indicated above.

Commissions of enquiry.

34. Commissions appointed under the preceding rule should ordinarly consist of the Chief Inspector and one independent person.

Reference in Annual Report.

35. A brief account of all accidents and their causes should be included in the Chief Inspector's Annual Report.

36. If in the course of an inspection or at any other time, the Inspector discovers damage which comes within the definition of an accident, but which has not been reported, he should report the facts at once to the Chief Inspector for action under Section 22 (*f*).

VII.—Appeals.

Filing of appeal.

37. Every petition of appeal shall be made in writing either in English or in the vernacular and shall bear a Re. 1 Court Fee Stamp.

Presentation of appeal.

38. An appeal may be presented either personally or by registered post to the Chief Inspector.

39. The petition of appeal shall be accompanied by the original order, notice or report appealed against, or by a certified copy thereof, or where no such order, notice or report has been made in writing, by a clear statement of the facts appealed against, the grounds of appeal and the referring section of the Act.

Form of Appeal.

40. On receipt of an appeal, the Chief Inspector shall, if the appeal is to be heard by himself, at once fix a date for hearing the appeal; and if it is to be heard by the appellate authority, obtain a date for the hearing of the appeal from the President of the Court. It is important that there should be no delay in the decision of appeals, as the stoppage of a boiler is likely to put the owner thereof to great inconvenience. The decision should ordinarily be given within 10 days from the receipt of the petition of appeal.

Fixing date for hearing.

41. When the date for hearing has been fixed, the Chief Inspector shall at once issue a notice to the appellant stating the date for hearing and informing him that if he wishes to be heard in support of the appeal or to produce evidence, he must be present either in person or by authorized agent with his evidence on the date fixed. The notice shall be sent to such address as shall be entered in the petition of appeal.

Procedure before hearing.

42. In all appeals the Chief Inspector shall decide whether the presence of the Inspector is necessary, and shall issue orders accordingly.

Presence of Inspector.

43. The Chief Inspector, when sitting as an appellate authority, and the appellate court shall have power to secure the attendance of witnesses and to make local enquiries under the provisions of the Code of Civil Procedure.

Attendance of witnesses.

44. If the appellant is not present on the date fixed, the appeal may be decided in his absence.

Ex parte decisions.

45. The Local Government shall appoint an officer to be President of the Appellate Court for such period as it thinks fit. The President shall be an officer with judicial or magisterial experience.

President of Appellate Court.

46. The Local Government shall constitute a panel of assessors for the purpose of assisting in the hearing of appeals. Assessors must be fully qualified mechanical engineers.

Panel of assessors.

47. Whenever the date for an appeal before the Appellate Court has been fixed, the Chief Inspector shall, under the orders of the President of the Court, arrange for the attendance of 3 members of the panel constituted under the preceding rule to act as Assessors.

Constitution of Appellate Court.

48. An assessor shall be entitled to a fee of R50 together with all travelling expenses incurred for any day on which he attends the appellate court.

Fees of Assessors

49. In appeals before the Appellate Court, the President is authorized to fix the costs and recover them from the appellant in any case in which the appeal is dismissed; in all cases of appeal in which a local inspection is required by the appellant he shall deposit in advance the full costs of such inspection.

Costs in appeals.

50. Any order on appeal authorizing the registering of a boiler or the grant or renewal of a certificate shall be deemed to be subject to the payment of such fees as are prescribed by rules or regulations framed under the Act.

Fees required for certificates granted on appeal.

FORM A.

_____ Boiler Inspection Department.

Register of Boilers.

1	2	3	4	5	6	7	8	9
Registry number.	Type of boiler.	Boiler rating.	Name of manufacturer.	Year and place of construction.	Date of registration.	Name of owner.	Place where in use.	Remarks. (Transfers, etc.)

In part II of the Register, Column 1 should contain the registry number and letters.

FORM B.

INDIAN BOILERS ACT, 1921.

Act ____ of 1921.

Notice for Examination of Boiler under Section 10.

No. _____ of 192 .

BOILER INSPECTION OFFICE,

Dated _____, *the* _____ *192*

To

_____

_____

_____

In reply to your application dated _____ you are hereby informed that Boiler Registry No. _____ at the above named premises will be $\frac{\text{thoroughly examined}}{\text{hydraulically tested}}$ by the Government Inspector on the _____

To enable the examination to be made, you are required to—

(*a*) afford to the Inspector all reasonable facilities for such examination and all such information as may reasonably be required by him;

(*b*) arrange that the boiler is properly prepared for examination in the prescribed manner;

(*c*) provide in the case of a boiler about to be registered such drawings, specifications and certificates as may be prescribed.

Voucher No. _____ in acknowledgment of $\frac{\text{Bank}}{\text{Treasury}}$ Receipt No. _____ for Rs. _____ accompanies.

Inspector of Boilers.

(*See reverse for preparation required.*)

(Reverse of Form B.)

PREPARATION FOR EXAMINATION.

SEE PART II, SECTION I OF THE REGULATIONS.

(A) Preparation for Thorough Inspection.

At every inspection of a boiler for the grant or renewal of a certificate, the boiler shall be empty and thoroughly clean in all its parts, all doors of manholes, handholes and sightholes and cleaning plugs and all caps in the headers and mud-drums of water-tube boilers, all firebars, bearers, front plates, bridge plates, fire-bridges, brick arches, oil fuel burners and mechanical stoker fittings shall be removed. All valves and cocks comprising the boiler mountings must be opened up and taken apart and the valves or cocks ground, where necessary, before the Inspector's visit.

Provision should be made for the removal of lagging or brickwork or other concealing part and for the drilling of plates, if required by the Inspector, and for verifying the pressure gauge and safety valve dimensions and weights. All smoke tubes, smokeboxes and external flues must be swept clean.

Provision must be made for the effective disconnection of all steam and hot water communication with any other boiler under steam. This must be effected either by the removal of a length of pipe from the steam, feed and blow-down piping or by the insertion of substantial blank flanges. Where blank flanges are employed, they must be inserted between the flange of the chest and the pipe attached to it. No blank flange shall be inserted between a safety valve chest and the boiler.

NOTE.—These provisions as to effective disconnection shall extend to every case wherein a person is sent or with the assent of the owner or person in charge goes, into a boiler for any purpose.

(B) Preparation for Hydraulic Test.

The chests of all mountings subject to steam pressure should be in place and shut tight or blank flanged. The safety valves should either be jammed down or removed, and the chest-opening blank-flanged. The attachment for the Inspector's pressure gauge and the nipple, when provided, for connecting the Inspector's test pump hose should be in order. All doors should be properly jointed and tightened up. The boiler should be completely filled with water, care being taken to allow all air to escape and, if possible, a preliminary test not exceeding the working pressure of the boiler should be taken before the Inspector's visit to test the tightness of the joints.

Preparation Now Required.—*(A), (B).*

NOTE.—The last certificate for the boiler should be shown to the inspector.

Counterfoil.

No.

FORM C.

PROVISIONAL ORDER UNDER SECTION 12 OF THE INDIAN BOILERS ACT OF 1921.

_____

_____

are hereby permitted to use the_____ Boiler Registry No._____

made by_____

and bearing Maker's Number_____ at a maximum pressure of_____ lbs.

per square inch pending the issue or refusal of a certificate within six months from the date hereof after which period this order will become void.

*Dated*_____

Inspector of Boilers.

N. B.—This order must be produced on demand by any authorised person and surrendered to the Chief Inspector on receipt of orders.

FORM D.

_____ BOILER INSPECTION DEPARTMENT.

Certificate Under the Indian Boilers Act of 192

Registry No. of Boiler _____ Type _____ Boiler Rating _____

Name of Owner _____ Place and year of manufacture _____

Situation of Boiler _____

I hereby certify that the above boiler is permitted by _____ me / the Chief Inspector under the provisions of Section 9 (1) / 8 (3) or 9 (1) of the Indian Boilers Act _____ of 192 to be worked at a maximum pressure of _____ lbs. to the square inch for a period of 12 months from _____ to _____

I further certify that the steam-pipe was tested hydraulically to a pressure of _____ lbs. per square inch last on _____

Inspector.

N.B.—Details regarding this boiler are recorded in Registration Book No. _____, of which a copy may be obtained on payment on application to the Chief Inspector.

(See reverse for "Conditions".)

Conditions.

(1) No structural alteration or renewal shall be made to the boiler otherwise than in accordance with Section 14 of the Act.

(2) Under the provisions of Section 9 of the Act this certificate shall cease to be in force on the occurrence of any accident as described therein, and the boiler shall not be used until a new certificate has been granted.

(3) The boiler shall not be used at a pressure greater than the pressure entered in the certificate as the maximum pressure nor with the safety valve set to a pressure exceeding such maximum pressure.

(4) The boiler shall not be used otherwise than in a condition which the owner reasonably believes to be compatible with safe working.

APPENDIX.

General working of Boilers. Instructions to Boiler Attendants.

These instructions should be frequently and carefully studied, with a view to keeping in mind the precautions to be observed, and the ordinary procedure to be followed in the safe working of boilers.

Precautions before starting the fires.

Before starting the fires in a boiler, the attendant should—

(1) see that there is sufficient water in the boiler and that the gauge cocks are working freely;

(2) ease safety valves, or open cock on top of boiler to allow air to escape,

(3) see that the blow-off cock is fully closed and tight;

(4) see that the safety valves and feed check valve are free and workable;

(5) see that water is not leaking from any part of the boiler;

(6) note if the pressure gauge pointer is at zero;

(7) see that the feed pump is in working order.

He must not rely on the supposition that the water he has previously put in is still in the boiler, as it may have run out without his knowledge through a leak or open cock, nor can he be sure that the gauge glass shows the true water level until he has tested it. This is done in the following manner: shut off the lower gauge cock and empty the glass by the drain cock; then shut the drain cock and open the gauge cock; if everything is in order, the water will then rise in the glass to the same height as before.

Raising steam.—In getting up steam in all types of boilers, the operation should be as gradual as circumstances will allow. Nothing turns a new boiler into an old one sooner than getting up steam too quickly. Forcing the fires when starting work is liable to cause straining of the seams and tubes of the boiler. In the case of large boilers generally, steam should not be got up in less than six hours. Before getting up steam, the water level should be observed, to ensure that water is at the proper height in the glass, the pressure gauge noted, and the safety valves tried to see they are free. The blow-off cock should be examined to see that it is completely shut and tight.

Pressure Gauge.—The pressure or steam gauge should be kept in order, and be in such a position as to be easily seen by the boiler attendant, There should be a plain mark on it showing the highest pressure allowed for the boiler, and the dial should be kept clean so that the figures may easily be read.

Steam Pressure.—Ordinarily the safety valve will prevent the steam from rising much above the working pressure, but if the steam gauge shows so rapid an increase of pressure as to indicate danger of exceeding the highest limit, water should be immediately fed into the boiler and the dampers partially closed in order to diminish the effect of the fire. If, however, the water has fallen so low that there is danger of an accident from this cause, the fires should be withdrawn before feeding in water, the safety valves eased, and if the engine is at rest, it should be started so as to reduce the pressure.

The Safety Valves are provided to guard against over-pressure. They should be moved by hand every day so as to prevent them from sticking. If moved only occasionally, they are liable to leak.

The valve can be tested by slowly raising it a little, and when let down, it should close perfectly tight. It should never be opened by a sudden knock or pull. If it does not close tight, turn it on its seat until it fits, or when its construction does not permit this, raise it slowly a few times and let it down again, but on no account must the valve be screwed down further or loaded more than what has been allowed by the Inspector.

Safety valves must never be overloaded, and spring valves should have ferrules or other provisions against their being screwed down too far. In case of an accident resulting from wilful overloading the culprit might be held criminally responsible at the official enquiry or inquest.

Low Water Safety Valves.—If there is a low water safety valve, test it occasionally by lowering the water level to see that the valve begins to blow at the right point. It should give warning "before" the water level has sunk too low, and before damage can be done. When the boiler is opened, examine the floats and lever and see that they are free and that they give the valve the full rise. With the ordinary type of high-steam and low-water safety valve the float should be down at its lowest position and the valve full open when the boiler is empty.

The Water Gauges.—These will be kept best in order by frequently blowing through. The cocks are thus kept in good working condition without leaking. Blow through the drain cock at the bottom of the gauge, and shut and open the steam and water cocks every few hours. These cocks should be blown through more frequently when the water is dirty. Should either of the passages become choked, or whenever the water in the gauge glass moves sluggishly, the passages must be cleaned. This is best done with a wire. The gauge glass is so arranged that its top cock connects with the steam space and its bottom cock is below the water line. The water line will ordinarily be near the centre of the glass tube. Always test the glass water gauges thoroughly the first thing in the morning and at the commencement of every shift. This is done by first opening the drain cock then shutting the upper cock which should give water; the upper cock should then be opened and the bottom cock closed—which should give steam; during this test the drain cock should be kept open.

If water and steam do not appear in proper order the cocks are choked and the passages should be cleaned. To lessen the risk of breaking the gauge glass the water cock should always be reopened after the steam cock.

Gauge glasses with a narrow white stripe running the whole length of the glass on the side next the boiler are recommended as they show the water line more clearly, especially when the water is dirty.

The Government Boiler Regulations require every water gauge glass to be fitted with a guard to prevent injury to the attendants. See that it is always in place, and clean, when there is steam in the boiler.

Special Note.—It does not follow that there is plenty of water in the boiler because there is plenty of water in the gauge glass. The passages may be choked, and empty gauge glasses are sometimes mistaken for full ones, and explosions have resulted therefrom. Hence the importance of keeping the gauge cocks perfectly tight and clean and of blowing through the test cocks frequently.

A large number of accidents have been due to inoperative water gauges, and to negligence of the attendant in not carefully reading the water level.

The Blow-off Cock.—The Blow-off should be used daily if the water is at all dirty or sedimentary, especially with Locomotive type and Vertical Boilers, as their narrow water spaces are liable to get choked with mud, which soon hardens into a solid mass. The amount of water to be blown out depends on the size of the boiler and can be determined only from experience. When blowing out the best result is obtained, if the water has been at rest for some time (say before the engine is started) thus giving the sediment time to settle; if the feed water is clean, merely turn the cock round.

The Scum Cock.—When scum cocks are fitted, if the feed water is dirty, a little should be blown off daily; if the water is clean, merely turn the cock round. Before opening the scum cock see that the water is at the height indicated by the water-level pointer, otherwise the scumming will be ineffective. Water should be blown from the surface through the scum cock when steam is being drawn off, *i.e.*, when the engine or other machinery is working.

Manhole and other door joints.—When making such joints, the jointing material should never be of round-sectioned packing. Care must be taken that the spigot of the door is centrally placed in the hole, as many accidents have resulted from packing being blown out between the spigot and side of hole, even when the clearance

was only $\frac{1}{8}$ inch. The nuts must be carefully and evenly tightened. Further tightening should be made during the process of heating up the boiler when raising steam.

Steam pipes.—When properly arranged, should give no trouble. Frequently, however, they are so designed as to contain pockets, in which, while out of use, condensed steam accumulates. Such water is exceedingly dangerous and great care should be taken to see that the pipes are properly drained *before the stop valve is opened*, otherwise "water hammer" will take place even with the best designed steam pipes, and disastrous explosions, causing loss of life and property, may occur.

Scale and grease.—Roughly speaking, scale offers a hundred times as much resistance to the passage of heat as does a similar thickness of steel or iron. A half inch furnace plate covered with $\frac{1}{10}$th inch scale is as efficient a heat retarder as a steel furnace 10 inches thick. Grease is about ten times worse than scale. In a boiler at work the temperature of a clean furnace plate is only slightly in excess of that of the water in the boiler; but if scale or grease is interposed between the water and the plate, the latter acquires a temperature more nearly approximating that of the flame with which it is in contact. If the fire is fierce (artificial draught) the furnace tube may grow so hot that it elongates considerably. If in addition, cold air is admitted during each firing, a concertina action of the furnace take place, which is one of the worst causes of boiler wear and tear.

Wear and tear.—Can be reduced and the life of a boiler prolonged if scale and grease are prevented from accumulating in a boiler. The combined effect of scale or grease and artificial draught are disastrous. Scale or grease also causes waste of fuel.

Grease.—A mixture of sedimentary water, soda, and grease produces an adhesive scum. Where this is suspected, the water level should never be lowered below the furnace top, unless the boiler is afterwards entered and this scum cleaned off the furnace plate before firing again.

Scale Removal.—The customary method is not a satisfactory one. The boiler is emptied and then cooled down by opening all the manholes, and the result is that the scale, which would otherwise be soft, hardens through contact with the air, and requires laborious chipping off.

A very effective, but slower method, is to retain the water in the boiler until cool, and not to run it out until the men are ready to enter the boiler with water hose, brushes and scrapers. The scale will then be soft and easily removable.

If time is a consideration, the cooling can be accelerated by adding cold feed to the hot water in the boiler and slowly running off the cooled water. Another method is to blow off the boiler with the lowest possible pressure (not more than 20 lbs.) and to keep it closed until cold. The scale will then be easily removed.

Treatment of feed water.—Many feed waters require soda or other chemicals to arrest corrosion or to change the nature of the scale.

There is *no harmless chemical* which will remove scale or sediment when it has once got into the boiler, and the only effective process is to purify the feed water before it enters the boiler. By this means the sediment, and generally, too, the added chemicals, can be deposited in tanks or in filters, and therefore never goes into the boiler. Excepting when the water obtainable is very good, water-purifying apparatus ought to pay any boiler owner, particularly at those works where three or more boilers are in constant work. Boiler owners wishing to have definite advice as to the best treatment of their feed water should have it analysed at some Chemical Laboratory and ascertain the best treatment in the particular circumstances.

Special attention is drawn to the not infrequent but *very bad* practice of allowing the waste steam from the Engine Cylinders or Pumps to be drained into the boiler Feed Water Tanks. The waste steam from cylinders is always mixed with a certain amount of oily matter, which will be deposited in the feed water tanks and ultimately be pumped into the boiler, with possibly disastrous results, as it will be obvious to every careful boiler attendant that should the oil be deposited on the furnace crowns, they may become over-heated and collapse.

It should be the first care of the Boiler Owner, and the Boiler Attendant to see that the feed water is kept as pure as possible. Impure feed water means additional expense on the upkeep of the boiler.

Preservation of boilers when not in use.—Steam boilers when not in use are liable to deterioration from corrosion, and, unless well cared for and made rust-proof, they may depreciate more rapidly than when in use. They should be thoroughly drained and thoroughly dried and all valves, cocks and openings closed so as to exclude moisture. Another plan is to fill the boiler with water to which about $\frac{1}{100}$ per cent. caustic soda has been added.

SPECIAL INSTRUCTION FOR BOILER NO. .....

This boiler should be opened up and thoroughly cleaned after a period of work which should not exceed ——— ——— ——— A record of such cleanings should be maintained and produced, when required by the Inspector.

Inspector of Boilers.

Dated _____

APPENDIX II.

No. A.-61.

GOVERNMENT OF INDIA.

BOARD OF INDUSTRIES AND MUNITIONS.

Simla, the 11th November 1920.

RESOLUTION.

THE Government of India have had for some time under consideration the desirability of eliminating the difficulties which at present exist in consequence of the diversity among the various Boiler and Prime Mover Acts in the different provinces of India. The question was examined by the Industrial Commission in paragraphs 221 and 222 of their Report. They found that "trouble was caused to persons who purchase boilers from other parts of India or desire to employ engineers who hold certificates from other provinces".

2. With regard to the certification of engineers and boiler attendants, the Commission did not find that, in provinces where certification is required, engineers were better qualified or accidents less frequent than in those where this is not the case; nor was the Commission of opinion that such certificates were of much use as a guarantee to the owners of small industrial plants of the competence of applicants for employment; while they thought that "the possession of a certificate gives a fictitious value to its holder, and makes it more expensive to employ him on small installations". They considered also that the demand for qualified engineers was increasing and must be met in some better way than by the existing arrangements for training certificated engineers and boiler attendants. Although the majority of such opinions, as have come before the Government of India, support the views taken by the Industrial Commission, the question is still not entirely free from doubt. It may be held to be a retrograde step in a country like India to remove the small safeguard which is at present furnished by the compulsory employment of a certificated engineer in charge of a boiler; and it is certainly the case that the necessity for this certificate has been an incentive, in the case of many candidates for industrial employment, to the acquisition of a training, however imperfect, in the management of steam engines.

3. The other main point considered by the Industrial Commission related to the diversity of standards at present required under local legislation in respect of boilers. It is clear that this diversity must necessarily cause inconvenience and actual loss to persons desiring to use in one part of India a boiler which has been certified in another; and the advantage to the industrial public would undoubtedly be considerable, if a uniform standard could be put in force throughout the country. The Industrial Commission recommended that the Government of India should draw up a series of technical rules for the guidance of inspectors in determining the pressure for which a boiler may be licensed throughout India, and should bring and maintain these rules up to date in a form applicable to the various modern types of boilers.

4. These questions were further considered by the conference of Directors of Industries held in Simla in April 1920; and the conference, while endorsing the views of the Industrial Commission regarding the certification of persons in charge of boilers, suggested that a small committee should be appointed to consider in what way

a uniform standard for steam boilers could be best introduced; and they recommended that the question of the abolition of certificates for persons in charge of boilers might also be considered by the same Committee.

5. In the rules which have been drafted by the joint Committee of the two Houses of Parliament under section 45-A of the Government of India Act (Schedule I, Part II, item 26-d), it has been proposed that the head "boilers" should be subject to legislation by the Indian Legislature; and if these rules are accepted by Parliament, no serious difficulty should arise in putting into effect the recommendations of the Industrial Commission, should they be supported by the further enquiry which has been proposed by the conference of the Directors of Industries and is accepted as desirable by the Government of India.

6. The Government of India have, therefore, decided to constitute a committee to enquire into matters discussed in this Resolution, and with the general object of a unification of the acts and regulations relating to the inspection, working and upkeep of boilers in India. The Committee would consist of the following gentlemen :—

President.

Mr. F. D. Ascoli, I.C.S.

Members.

Mr. R. P. Adams, O.B.E., A.M.I.E., Chief Inspector of Factories, Bengal.

Mr. D. R. MacIntosh, Chief Inspector of Steam Boilers, Bombay.

7. The terms of reference are as follows :—

(*a*) To consider the desirability or otherwise of retaining the law at present in force in certain provinces requiring persons in charge of boilers to possess certificates.

(*b*) To consider the possibility of introducing a uniform standard throughout India for steam boilers.

(*c*) Generally, to enquire into the possibility of the unification of the laws and regulations relating to the inspection, working and upkeep of boilers, and to prepare and submit such proposals as they may think suitable for this purpose.

Ordered, that a copy of this Resolution be forwarded to all Local Governments and Administrations, with the request that the Committee may be given any assistance which they may require and that any applications for information which may be made by the Committee may be complied with.

Ordered also that a copy of the Resolution be forwarded to all Departments of the Government of India, to the Controller of Printing, Stationery and Stamps, to the President and Members of the Committee, and that the Resolution be published in the Supplement to the *Gazette of India*.

J. C. B. DRAKE,

Secretary, Board of Industries and Munitions.

No. A.-61.

GOVERNMENT OF INDIA.

BOARD OF INDUSTRIES AND MUNITIONS.

Delhi, the 19th November 1920.

RESOLUTION.

In supersession of paragraph 6 of the Government of India, Board of Industries and Munitions, Resolution No. A.-61, dated the 11th November 1920, it is notified that as Mr. Adams who is at present absent on leave will not be able to return to India in time to join the Boiler Laws Committee, the Government of India have decided to appoint Mr. D. B. Mann, M.B.E., Officiating Chief Inspector of Factories, Bengal, to be a member of the said Committee in place of Mr. Adams.

Ordered, that a copy of this Resolution be forwarded to all Local Governments and Administrations.

Ordered also that a copy of the Resolution be forwarded to all Departments of the Government of India, to the Controller of Printing, Stationery and Stamps, to the President and Members of the Committee, and that the Resolution be published in the Supplement to the *Gazette of India*.

J. C. B. DRAKE,

Secretary, Board of Industries and Munitions.

APPENDIX III (*a*).

BOILER LAWS COMMITTEE.

INSTRUCTIONS TO PERSONS INVITED TO GIVE EVIDENCE BEFORE THE COMMITTEE.

(Answers are not expected to questions except those of which each individual witness or the body or association which he represents has actual knowledge or experience.)

(1) The questions in the accompanying list have been framed in order to cover, so far as practicable, all the points included in the terms of reference.

(2) For convenience of reference, that part of the Report of the Indian Industrial Commission which deals with the administration of the Boiler Acts is reprinted in Appendix A.

*Paragraphs 221 and 222 at pages 144—145 of the Report of the Indian Industrial Commission.

(3) The law and regulations regarding the inspection, working and upkeep of boilers are contained in seven different Acts,* amplified by different sets of rules framed under the Acts. The appointment of certificated engineers, where required, is laid down in the Acts themselves; detailed instructions for the inspection of boilers and for boiler standards are prescribed in rules and regulations. It is accordingly necessary to distinguish between the possibility and advisability of unifying the Acts on the one hand and rules and regulations on the other for the whole of India.

*Bengal Act, III of 1879 (in force also in Bihar and Orissa).
Bombay Act, V of 1917.
Madras Act, III of 1893.
United Provinces Act, III of 1915.
Punjab Act, II of 1902.
Burma Act, II of 1910.
Central Provinces Act, II of 1907.

(4) It is necessary to bear in mind that under the Reform Scheme it is proposed that legislation regarding boilers should rest with the Government of India, while the administration of the Acts should remain with Provincial Governments.

QUESTIONNAIRE.

1. State the nature and extent of the experience that you have had of the boiler law of your province or of other areas.

I.—Certificated Engineers.

2. Is it in your opinion advisable that all persons in charge of boilers, or alternatively all persons in charge of boilers exceeding a specified horse power, should possess certificates? Please state your reasons.

3. Can you state from experience whether accidents to boilers are more frequent in areas where certificated engineers are not by law required? Are boiler engineers in such areas generally less technically qualified than in others?

4. Is there any reason to think that certificated engineers may be necessary in certain areas and not in others? If so, would you leave it to Provincial Governments to decide where they are necessary?

5. (*a*) If your answer to question 2 is in the affirmative, should a certificate granted in one province be valid in all others? (*b*) What qualifications would you accept in lieu of the ordinary certificate?

6. If your answer to 5 (*a*) is in the affirmative, would it be necessary to have certificates of different standards? How would you propose to maintain uniformity in certificates of one or more standards granted in different provinces?

7. Please state your views (if any) on the syllabus for a certificate examination (if required) and on the constitution of the examining bodies.

8. Is it a fact that employers dislike certificated engineers on the ground that they are generally not prepared to do practical work in the engine-house because their retention is compulsory?

9 Is it your opinion that where certificates for boiler engineers are compulsory, the desire for a certificate as a boiler-engineer interferes with the ordinary training of a mechanical engineer? If so, could this be remedied by an alteration in the syllabus for the certificate?

II.—Introduction of a uniform standard.

10. What practical disadvantages can you point to which arise from the adoption of different standards for boilers in different provinces? Have any such instances been brought specifically to notice?

11. Are there in your opinion any technical reasons why different standards should be adopted for different parts of India?

12. Can you point to any practical difficulties in laying down a uniform standard or standards for the whole of India?

13. What criticism have you to offer of the standard prescribed in your province or in any other area of which you have experience? Are the existing rules or regulations applicable to all modern types of boilers? Please give details for any alteration that you may suggest in the regulations.

14. (*a*) Assuming that you are in favour of a uniform standard or standards, do you agree that the technical rules for the guidance of inspectors should be framed by the Government of India (*b*) Assuming that Provincial Governments will administer the working of the Act, would you give them any power to modify the technical rules relating to the standard and for determining the pressure for which a boiler may be licensed, (1), subject to the control of the Government of India or (2) on the authority of the Provincial Governments only.

15. Assuming that your answer to 14 (*a*) is in the negative, can you suggest a practical alternative method of securing uniformity?

16. Do you agree that a certificate given for a boiler in one province should be valid throughout India during its continuance, subject to registration in the province in which it is used?

III.— Unification of the law.

Note.—[The important differences in the existing Acts may be classified as follows:—

(*a*) Extent of application to local areas.
(*b*) Exclusion of certain classes of boilers.
(*c*) Inclusion of prime-movers and other machinery.
(*d*) Appointment and control of inspection staff.
(*e*) Appellate authorities.
(*f*) Examination and appointment of certified engineers.]

III(a).—Extent of local application.

17. Are there any reasons (apart from difficulties of inspection) why the Act should not be applicable to boilers wherever situated? If so, would you give Local Governments power to exclude areas by notification, or should the power be exercised by the Government of India?

18. What areas in your province are at present excluded from the operation of the existing Act and for what reasons?

III(b).—Exclusion of certain classes of boilers.

19. What classes of boilers in your province are excluded from the operation of the existing Act (*a*) absolutely by the Act itself, (*b*) by rules made under the Act? Is

their exclusion suitable? If not, what classes of boilers should be absolutely excluded, and what classes liable to exclusion by rules or notifications under the Act.

20. Would the same principle as regards exclusion apply to both of the above classes throughout India? Should the power to exclude in either case rest with the Government of India or with the Provincial Government?

21. In particular should boilers used for agricultural purposes be excluded from the operation of the Act? Please state your reasons. Would you also exclude boilers used (*a*) in tea gardens, (*b*) indigo factories, (*c*) for sugar-cane crushing?

III (c).—Inclusion of prime-movers and other classes of machinery.

22. Please state to what extent the present Act is applied in the inspection of prime-movers or other classes of machinery. Is this inspection efficacious or necessary?

23. Having regard to section 18 of the Indian Factories Act (XII of 1911), do you think that any necessity exists for similar safeguards in establishments that do not come within the operation of the Factories Act?

III (d).—Appointment and control of inspecting staff.

24. What is the present constitution of the Boiler Inspecting Staff in your province? Are the appointments made by Government or by some other body? Under whose control does the staff work?

25. If the Act be extended to the whole of your province, and not only to notified areas, what increase, if any, in the inspecting staff would be necessary?

26. Do you accept the findings of the Public Services Commission that the boiler inspectors should be Government servants paid from general revenues and not from a fund established *ad hoc* and that in all the larger provinces there should be a chief or senior inspector responsible for the effective working of the staff? If so, should this be definitely laid down in the Act?

27. It was proposed by the Indian Industrial Commission that boiler inspection should be under the administrative control of the Provincial Department of Industries. Do you think that control by the Director of Industries and the chief or senior inspector would be sufficient, or would further control be necessary, *e.g.*, by the District Officer? How far should the general power of control be prescribed by the Government of India, and how far left to the authority of Provincial Governments?

28. In some provinces control is exercised by a Boiler Commission; this principle was condemned by the Public Services Commission, who held it to be unsound that representatives of the interests to be inspected should have a voice in the management of the inspection department; the system has been justified as a mitigation of the severity caused by differences of the law and regulations in different provinces. Do you accept the finding of the Public Services Commission, especially if the law and regulations are unified throughout India?

29. If the Act be extended to the whole of a province and not only to notified areas, would the control of a Boiler Commission for each province be effective?

30. As Provincial Governments will be responsible for the administration of the Act, do you agree that they should be responsible for framing detailed rules for inspection (excepting the rules referred to in question 14), based on model rules to be framed by the Government of India?

III (e).—Appellate authorities.

31. Describe the system of appeal and the constitution of the appellate authority at present in force in your province. Is the system satisfactory, or what alterations would you suggest?

32. In view of the fact that appeals are concerned with technical matters is it your opinion that the appellate authority or the assessors (if any) or both should be experts?

33. Would a single appellate authority suffice for the whole of your province?

34. Is there in your opinion any reason for the constitution of appellate bodies of different types (*a*) in different provinces, (*b*) in different parts of your province?

Extract from the Report of the Indian Industrial Commission, 1916-1918.

* * * * *

THE ADMINISTRATION OF THE BOILER AND PRIME-MOVER ACTS.

Diversity of practice in various provinces.

221. With reference to the Administration of the various provincial Boiler and Prime-Mover Acts, there is a great diversity of practice all over India, which causes trouble to persons who purchase boilers from other parts of India or desire to employ engineers who hold certificates from other provinces. We have enquired closely into the question of the certification of engineers and boiler attendants. We do not find that in provinces where certification is required, engineers are better qualified or accidents less frequent than in those where this is not the case. It is urged that these certificates are to some extent a guarantee to owners of small industrial plants of the competence of applicants for employment. We do not attach much importance to this argument, and it will have still less weight if owners and employers have the advice of a local Department of Industries to help them. On the other hand, it is undoubtedly the case that the possession of a certificate gives a fictitious value to its holder, and makes it more expensive to employ him on small installations. It is true that certain educational institutions owe many of their pupils to the fact that they prepare them for boiler certificate examinations, but this is beside the point. The demand for qualified engineers is greatly on the increase, and a better class of man than the mere "engine driver" must be provided for the larger organised industries.

Accidents are usually due either to carelessness, or to defects in the plant. When due to ignorance, which is seldom, they are likely to occur during the absence of the responsible attendant, a possibility that is at least as great in provinces which insist on certificates as in those which do not. It must also be remembered that at present the law does not apply to the case of internal combustion engines, which are not less liable to accidents in their way than steam engines.

Recommendations of the Commission.

222. The Boiler Inspection Department is considered at length in the report of the Public Services Commission (page 126). The Commissioners lay down four principles for general guidance :—

"In the first place, the time has come to make the boiler inspectors Government servants in every respect, like the factory inspectors, and to pay from general revenues both their salaries and their pensions, irrespective of the amount of fees earned. Secondly, expert supervision of the inspecting staff is essential. Police officers and members of the Indian Civil Service do not possess the necessary technical qualifications. Thirdly, the present system, by which in certain places representatives of the interests to be inspected have a voice in the management of the inspection department, is unsound, and should be abolished. Fourthly and finally, there should be one officer in each of the larger provinces who should be responsible for the effective working of the inspection staff. He should be called either a chief or first inspector according as the work to be done is on a large or small scale."

We endorse these recommendations, and would add the following :—

(1) Boiler inspection should be a duty of the provincial Departments of Industries.

(2) The Imperial Department of Industries should draw up a series of technical rules for the guidance of inspectors in determining the pressure for which a boiler may be licensed throughout India and should bring and maintain these rules up to date in a form applicable to the various modern types of boilers.

(3) The laws compelling persons in charge of boilers to possess certificates should be abolished.

The second and third of these proposals would involve legislation.

* * * * *

APPENDIX III (*b*).

Additional Technical Questionnaire.

It is proposed to formulate a set of rules for the material, design and construction of land boilers for the whole of India and the Committee would be glad to have your opinion on the following points :—

Standard Regulations.

1 (*a*) Should the standard conditions to be laid down in the rules for material design and construction of the various parts constituting a boiler (based on the latest Board of Trade Rules and on the recommendations of the British Marine Engineering Design and Construction Committee) be adhered to by the Boiler Inspection Departments in India to the extent of excluding all boilers not complying with the standard rules? (*b*) or do you think that boilers not complying with the standard rules in the matter of tests of material and being built under the supervision of an inspecting authority should not be entirely shut out but be granted certificates at a lower pressure than would otherwise be granted?

Steam-pipes.

2. (*a*) Should main steam-pipes be inspected by the Boiler Inspectors? (*b*) If so, should all main pipes irrespective of size or pressure be inspected? (*c*) At what intervals after the initial inspection should they be reinspected? (*d*) What kind of periodical inspection should be made? (*e*) Would external inspection and hydraulic test in place be sufficient? (*f*) Should the boiler rules specify tests for material of steam-pipes? (*g*) Should cast iron as material for steam-pipes be prohibited for future main steam-pipe installations? (*h*) Should the date of hydraulic test and pressure to which steam-pipes were subjected be shown in the boiler certificate? (*i*) Do you consider that provision should be made in the rules for the effective disconnection of steam and hot water communication with another boiler during inspection or at any time when a person has to go inside? (*j*) If so, what in your opinion would be effective disconnection?

Safety Valves.

(*a*) Should there be more than one safety valve on a boiler?

(*b*) If so, should one be a lock up valve?

(*c*) What in your opinion should be the minimum diameter of safety valve?

(*d*) If two safety valves are desirable, would you agree to them being in one chest?

(*e*) Should a tee piece or distance piece be allowed between the safety valve chest and the boiler?

(*f*) Would you consider a safety valve chest to which the main stop valve is bolted a satisfactory arrangement?

(*g*) In the case of some locomotive type boilers having the engine on top it is the practice to place the safety valves on the cylinder casing instead of on the boiler itself. A cast iron passage-way of appreciable length is thus interposed between the boiler and safety valve. Do you consider this practice satisfactory?

Manholes.

(*a*) Should a manhole in the barrel of a locomotive type boiler be required by the rules?

(*b*) If so, should a full sized manhole be required in barrels over a certain diamater?

(*c*) What do you consider this diameter should be?

(*d*) What size of manhole or sight-hole should be required for barrels below that diameter?

Nominal Horse Power.

(*a*) Should the term "N. H. P." of boilers be retained in the certificate?

(*b*) If not, what would you suggest should take its place?

(*c*) By what means should a boiler be rated for inspection fees—on the fire grate area or on the heating surface?

(*d*) If on the heating surface, what rule would you employ for its measurement?

Tube Plates.

(*a*) Tube plates of locomotive type boilers and certain multitubular vertical boilers usually have no stays or stay tubes in the body of the plate. Should stay tubes be required by the rule for all tube plates or would you agree to accept tube plates under a certain size without stays?

(*b*) If so, what would you consider a suitable maximum diameter of barrel beyond which stay tubes would be required?

(*c*) Should any account be taken of the holding power of ordinary tubes expanded into parallel or tapered holes?

(*d*) If so, can you suggest a rule for same?

APPENDIX IV.

Proceedings of a Conference of Mechanical Engineers held in Calcutta on the 7th January 1921.

Mr. MacIntosh in opening the discussion stated that the opinion of the gentlemen present was principally wanted on the supplementary questionnaire on technical matters connected with the design and construction of Land Boilers for India, but before dealing with that subject referred briefly to the general questionnaire and asked for an opinion on :—

(*a*) Whether it was considered necessary to have certified engineers in charge of Boilers. This subject was fully discussed and the representatives present were unanimously against any law compelling a Boiler attendant to be a certificated Engineer.

(*b*) Introduction of a uniform standard for boilers in India. All agreed that there should be a uniform standard for the design and construction of boilers for the whole of India, that the technical rules should be framed by the Government of India, and that the boiler certificate should be valid throughout India.

(*c*) Unification of the law and extent of local application. Opinion was unanimous that there should be unification of the law and that the Act should be applicable to boilers wherever situated.

(*d*) Exclusion of certain classes of boilers. Messrs Stark, Agate and Skinner were of opinion that all locomotive and other boilers appertaining to railways as defined under the Railway Act and boilers coming under Marine Survey should be excluded. Mr. Adams expressed the opinion that boilers appertaining to Railways other than Locomotives, boilers of steam launches not coming under Marine Survey and boilers controlled by the Port Commission should be inspected by the Boiler Inspection Department.

(*e*) Inclusion of Prime-movers and other classes of machinery. Opinion was unanimous that prime-movers should be excluded from the Act.

(*f*) Appointment and control of inspecting staff. After some discussion it was finally agreed that the need for a Boiler Commission no longer existed as the Chief Inspector would be a whole-time officer coming directly under the control of the Director of Industries, who would have an Advisory Board to assist him in dealing with technical matters, but the gentlemen present wished it to be clearly understood that they did not agree with the findings of the Public Services Commission.

The supplementary questions on purely technical matters were then taken up. Mr. MacIntosh explained what it was proposed should be done as each point came up for discussion—

(*a*) *Standard regulations.*—Messrs Agate, Stark and Skinner were of opinion that boilers not complying with the standard rules should be granted certificates at a lower pressure than would otherwise be granted and that the penalty should be such as to discourage any deviation from the standard rules. Mr. Adams was of opinion that all boilers not fully complying with the standards laid down should be treated as second-hand boilers and penalised accordingly. After considerable discussion Mr. Adams agreed to accept the findings of the majority.

(*b*) *Steam pipes.*—1. Opinion was unanimous regarding the necessity of inspecting main steam-pipes.

2. There was some difference of opinion regarding the necessity of inspecting small pipes of under 3 inches diameter but it was generally considered that for the sake of uniformity it might be advisable to include all main steam pipes, which would be clearly defined as meaning only the pipe from the main boiler stop valve to the prime-mover or first user.

3. Mr. Stark thought the interval after the initial inspection should be the same as that laid down by the Board of Trade. This was considered not quite suitable for land boilers and after a discussion and a statement by Mr. MacIntosh of the evidence we had hitherto had on the subject, it was unanimously agreed that an interval of five years would be satisfactory.

4. All agreed that an external inspection and hydraulic test in place would be sufficient after the first inspection.

5. Opinion differed as to whether it was necessary that the boiler rules should specify tests for the material of main steam pipes. Mr. Adams considered it was necessary but the others were of opinion that it would be sufficient if the pipes were found to be sound and of good manufacture at the initial inspection.

6. Considerable discussion took place on the use of cast iron for main steam pipes. Mr. Adams was of opinion that cast iron should not be permitted and quoted fatal accidents which had occured through its use. Messrs. Agate and Stark considered that cast iron main steam pipes might be allowed up to a pressure of 80 lbs as most boilers were being worked over that pressure and this limitation would practically rule them out. Mr. Skinner then stated that a considerable number of boilers were being worked at 80 lbs. in Bengal and were still being imported. Mr. Stark then proposed a limit of 70 lbs. but on further discussion it was agreed that the limitation was merely evading the question at issue and it was subsequently unanimously agreed that cast iron for main steam-pipes should be prohibited altogether for all new installations or renewals of main steam pipe ranges.

7. It was agreed that a certificate was not necessary for steam pipes and that it would be sufficient if the date of test was entered on a foot-note of the Boiler certificate.

8. Opinion was unanimous that provisions should be made in the rules for the effective disconnection of steam and hot water communication with another boiler when any person had to go inside and that effective disconnection should mean either the taking out of a length of pipe (which was preferable) or efficient blanking of the various pipes, steam or water.

Safety Valves.

(*a*) Opinion was unanimous that there should be two safety valves on all boilers.

(*b*) There was some discussion as to the necessity of a lock-up valve, but after Mr. MacIntosh had given his experience of their uselessness in practice, it was finally agreed that there was no necessity for a lock up valve.

(*c*) *Minimum diameter of safety valve.*—Mr. Adams suggested a minimum of one inch. Mr. MacIntosh stated that up to seven or eight years ago in Bombay a minimum of two inches had been required and since then a minimum of one inch had been laid down and a smaller diameter could be accepted at the discretion of the Chief Inspector. Mr. Adams thought that the acceptance of a smaller diameter than one inch should not be left to the Chief Inspector, but that a rule should be framed for such contingencies and laid down in the rules. After some discussion it was finally agreed that a minimum of one inch diameter should be laid down in the rules and the Chief Inspector given power to accept a smaller diameter for very small boilers, provided that the total area was sufficient to meet the rules for safety valves.

(*d*) All agreed that two safety valves on one chest should be accepted.

(*e*) Opinion was unanimous that a tee piece or distance piece between the safety valve chest and the boiler should not be allowed but in exceptional cases such as certain types of locomotive boilers having an engine on top safety valves might be placed on the cylinder casing instead of on the boiler itself but wherever possible one safety valve should be on the boiler itself.

(*f*) Opinion was unanimous that a safety valve chest to which the main stop valve is bolted is unsatisfactory and should not be allowed.

Manholes.

(*a*) All were of opinion that the rules should require a full sized manhole for locotype boilers with barrels over 3 feet in diameter and

(*b*) For barrels below that diameter manholes or sightholes would be sufficient.

Nominal Horse Power.

Every one agreed that this term was obsolete, useless and misleading, that a more appropriate term for calculating the fees for inspection was required. Both evaporative capacity and heating surface were suggested and after some discussion it was agreed that the term "Boiler Rating" based on the approximate heating surface should be used and that a rule should be framed taking in the principal dimensions of the heating surface.

Tube Plates.

(*a*) Opinion was unanimous that in locomotive type and certain multitubular vertical boilers tube plates under a certain size do not require stays.

(*b*) There was some difference of opinion regarding a suitable maximum diameter of barrel beyond which stay tubes would be required but it was ultimately agreed that the maximum should be 3 feet.

(*c*) All were of opinion that account should be taken of the holding power of ordinary tubes expanded into parallel or tapered holes, but no rules could be suggested.

Approved. H. E. SKINNER,—8-2-1921.

Approved. H. R. STARK,—9-2-1921.

Approved. R. P. ADAMS,—11-2-1921.

Approved. C. AGATE,—11-2-1921.

APPENDIX V.

Summary of Tour.

Dates on which evidence was heard.	Place.	Number of Witnesses.		Remarks.
		Documentary evidence.	Oral evidence.	
November.				
27th to 30th .	Lahore . .	7	9	
December.				
3rd to 4th .	Karachi . .	3	9	
8th to 11th .	Bombay . .	10	12	
13th to 14th .	Ahmedabad .	9	6	
20th to 22nd .	Nagpur . .	16	14	
January.				
3rd to 6th .	Calcutta . .	18	21	Also Conference of Mechanical Engineers.
10th . .	Jamshedpur .	...	1	
15th . .	Coimbatore .	3	3	
17th to 21st .	Madras . .	11	11	
28th to 2nd Feby.	Rangoon . .	8	12	
February.				
9th . . .	Shillong . .	...	8	Conference.
12th . .	Patna . .	4	3	
14th to 17th .	Cawnpore .	23	21	
19th . .	Agra . .	1	1	
	Total .	113	131	

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