

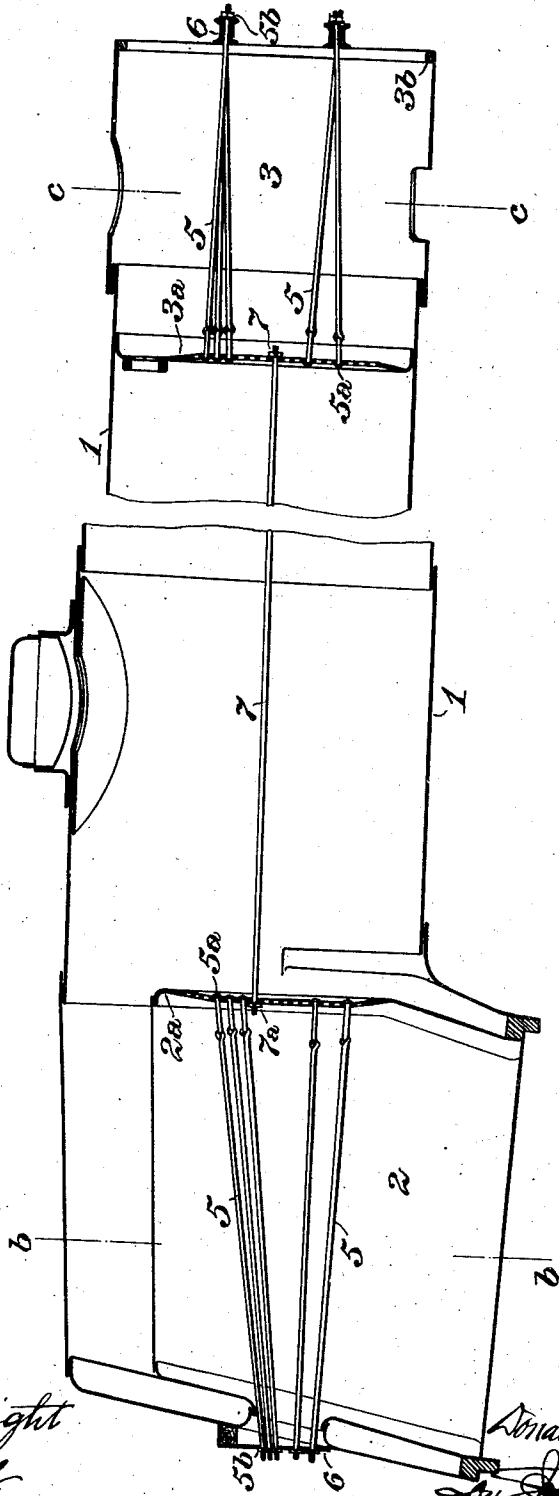
D. R. MacBAIN.
MANUFACTURE OF STEAM BOILERS.
APPLICATION FILED JAN. 3, 1911.

1,002,413.

Patented Sept. 5, 1911.

3 SHEETS-SHEET 1.

FIG. 1.



WITNESSES

Edward A. Wright
S. R. Bell

INVENTOR

Donald R. MacBain
J. H. ...

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3 SHEETS—SHEET 2.

FIG. 2.

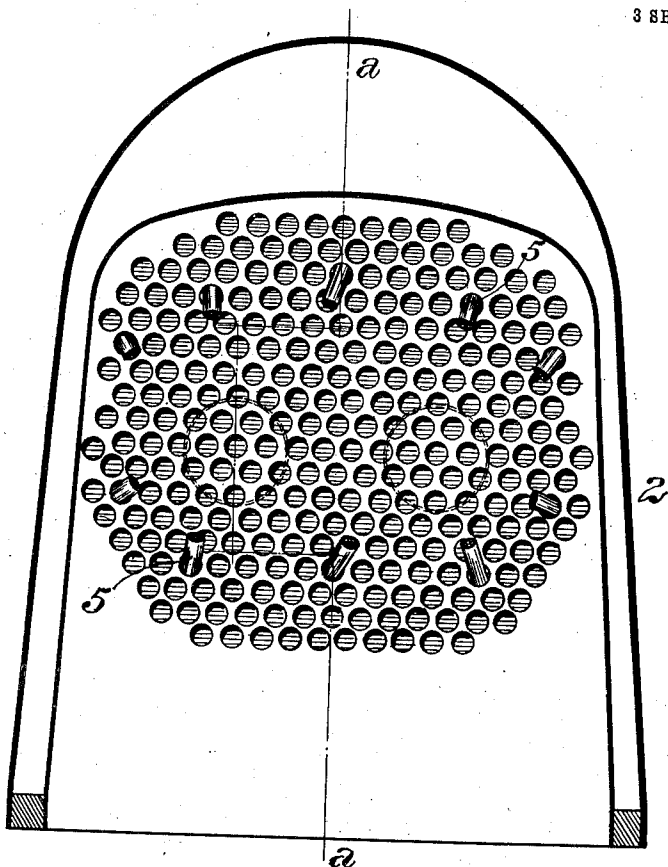
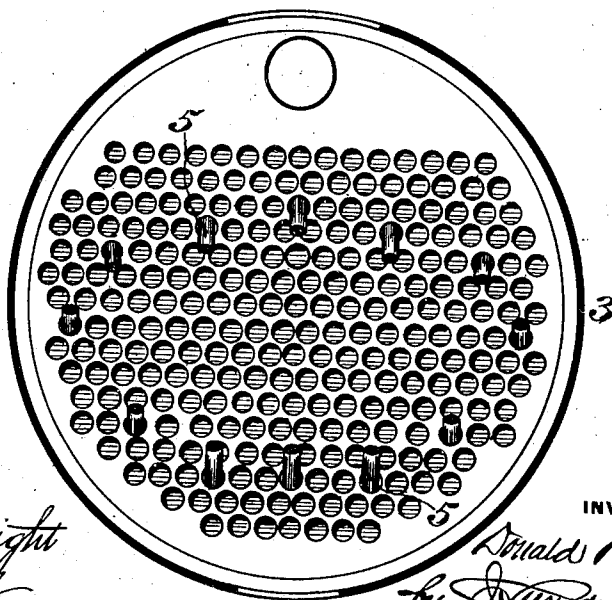


FIG. 3.



WITNESSES

Edward Wright
S. R. Bell

INVENTOR

Donald V. MacBain
by S. Mendenhall, atty.

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3 SHEETS—SHEET 3.

FIG. 4.

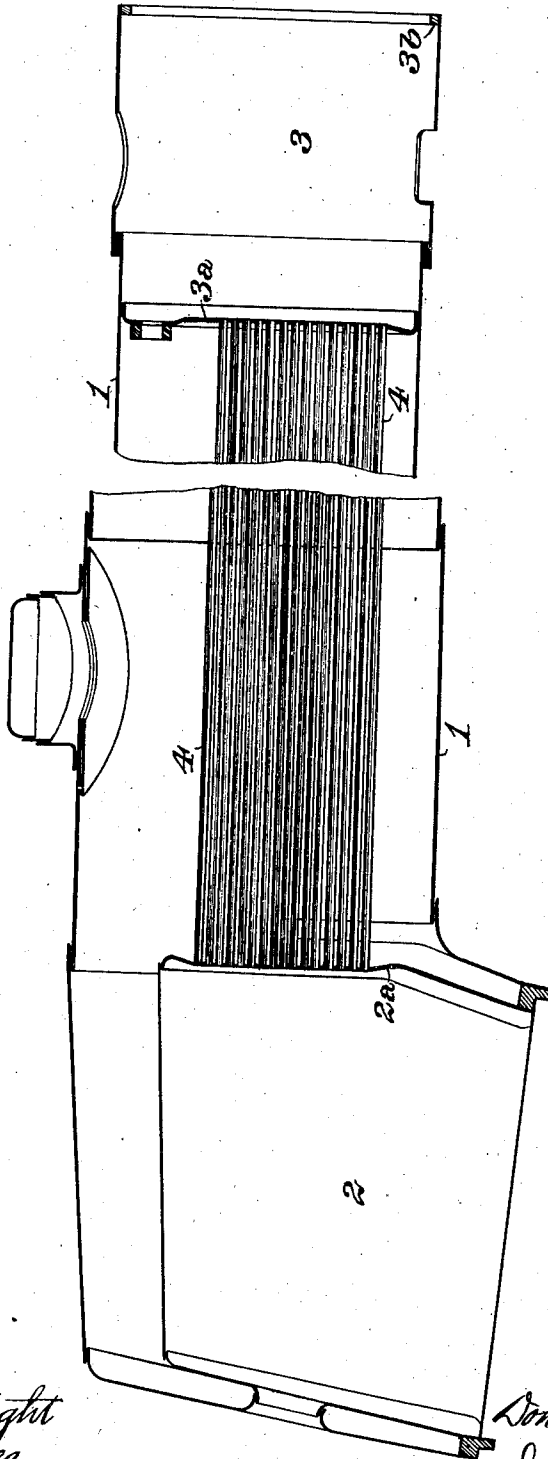
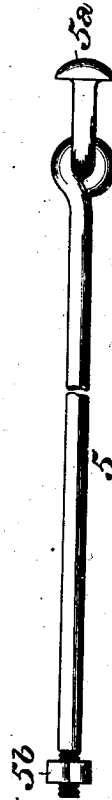


FIG. 5.



WITNESSES

Edward Wright
S. A. Bell

INVENTOR

Donald R. MacBain

by [Signature] Att'y

UNITED STATES PATENT OFFICE.

DONALD R. MACBAIN, OF CLEVELAND, OHIO.

MANUFACTURE OF STEAM-BOILERS.

1,002,413.

Specification of Letters Patent.

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To all whom it may concern:

Be it known that I, DONALD R. MACBAIN, of Cleveland, in the county of Cuyahoga and State of Ohio, have invented a certain new and useful Improvement in the Manufacture of Steam-Boilers, of which improvement the following is a specification.

My invention relates to steam boilers of the class in which a plurality of tubes is inclosed within a shell or body, more particularly those of the "locomotive" type, and its object is to provide means whereby the detrimental action of the unequal expansion of the tubes and shell of the boiler will be effectually counteracted, and the objections resultant upon such unequal expansion be eliminated in the operation of the boiler.

To this end, my invention, generally stated, consists in a novel method of treating boiler tube sheets and securing boiler tubes thereto, in such manner as to impose a compressive strain upon the tubes which acts in opposition to the tensional strain imposed upon them in service by the expansion of the boiler shell; also, in a tubular steam boiler in which are combined two tube sheets which are sprung outwardly, but without permanent set, in the direction of the length of the tubes, and a plurality of tubes, connected, at their opposite ends, to said tube sheets.

The improvement claimed is hereinafter fully set forth.

In the accompanying drawings: Figure 1 is a vertical longitudinal section, on the line *a a* of Fig. 2, through the shell of a steam boiler, illustrating the preliminary operation of the application of my invention; Figs. 2 and 3, transverse sections, on an enlarged scale, through the same, on the lines *b b* and *c c*, respectively, of Fig. 1; Fig. 4, a longitudinal central section, showing the boiler completed in accordance with my invention; and, Fig. 5, a view, in elevation, of a tension rod.

My invention is herein set forth as applied in the manufacture of a steam boiler of the type which is well known in the art, and is now substantially standard in locomotive engines, and which comprises, as essential elements, a shell or waist, 1, a firebox, 2, at the rear end thereof, a smoke box, 3, at the front end thereof, and a plurality of fire tubes, 4, extending between and secured at their opposite ends to, a firebox tube sheet, 2^a, at the front of the firebox,

and a front tube sheet, 3^a, adjoining the rear of the smoke box.

The successful operation, in practical railroad service, of locomotive boilers of the construction above described, particularly when fitted with superheater tubes of comparatively large diameter, which are in use to a considerable extent, has been and is materially impaired by leakage at the joints between the tubes and the firebox tube sheets, such leakage involving waste of fuel, delays of trains, and loss of time and expense in frequent repairs. It has been conclusively demonstrated that, with a high firebox temperature and rapid circulation of water, the expansion of the shell of the boiler, between the tube sheets, is greater than that of the tubes, from which unequal expansion there results the exertion of tensile strain on the tubes and their connections to the tube sheets. If the tubes were, or could be, so connected to the front tube sheet as to be capable of slipping therein, that is of moving longitudinally relatively thereto, without leakage at their joints with the sheet, the difference of expansion would be compensated without objectionable results, but as the tubes are rigidly connected to the front tube sheet, the tensile strain is exerted upon the tube beads at the firebox tube sheet, straining them to such an extent that upon a slight reduction of the temperature of the boiler, leaks will be caused between the tubes and tube sheets. As is well recognized by those familiar with the operation of locomotives, this leakage is a serious objection in service.

Inasmuch as the condition of unequal expansion of the shell and tubes, which is the cause of the leakage of the latter, by imposing tensile strain upon them, cannot be prevented, my invention is designed to prevent its effect upon the tubes from being injurious, by imposing upon them a counteracting strain in the opposite direction, *i. e.*, one of compression, and thereby instituting a balance of forces which will eliminate the objectionable result produced in steam boilers of the ordinary construction. To this end, in the practice of my invention, the tube sheets are, prior to the setting of the tubes therein, sprung slightly outwardly, but without imposing upon them a permanent set, and are held in this position. The tubes, except those that are temporarily omitted for the application of the spring-

ing devices, are then inserted in the tube sheets, and secured therein by prossering, rolling, or expanding them in any suitable known manner. The springing devices are then removed, and the remainder of the tubes inserted in their places, and secured in the tube sheets as above described. The entire set of tubes will then be subjected to slight compressive strain, by reason of the pressure exerted upon their ends by the tendency of the outwardly sprung tube sheets to resume their original flat form, and such strain of compression will counteract and compensate the tensile strain exerted upon the tubes by the increased expansion of the shell.

Referring to the drawings, the operations above described may be readily and conveniently performed by first exerting the requisite outward tensile strain upon the tube sheets by the application to each of them, before the insertion of the tubes, of a plurality of tension rods, 5, which are passed through holes in the tube sheets, in which tubes are subsequently inserted, these holes being located as near as may be to those of the upper and lower rows of tubes. The tension rods are provided with T heads, 5^a, which bear against the inner sides of the tube sheets, and are formed in two sections, linked or coupled together near the T-heads, so that the latter may be inclined to pass through the holes in the tube sheets and set to bear against the inner sides thereof. The opposite ends of the tension rods are screw threaded and provided with nuts, 5^b, which are adapted to abut against bearing plates or bars, 6, fitting against the rear of the fire-box, 2, and the front ring 3^b, of the smoke box, 3, respectively. The tension rods are spaced at substantially uniform distances apart, so as to equalize, as far as practicable, the strain on the tube sheets, and by screwing up the nuts, 5^b, the tube sheets are sprung slightly outwardly, as, say about 1/16 of an inch or more, as shown in Figs. 1 and 4, but not sufficiently far to give them a permanent set.

In order to prevent the coning of the sheets centrally between the tension rods, if such tendency should be developed, a limit rod, 7, having nuts, 7^a, on its ends, may be passed through holes in the tube sheets on the vertical center line of the boiler, midway between the upper and lower rows of tension rods, and the nuts, 7^a, screwed up to such distance apart as will limit the outward spring of the middle portions of the sheets to the degree desired.

When the tube sheets have been sprung outwardly as above described, and while they are still held in this sprung condition by the tension rods, 5, the tubes are inserted in the holes in the tube sheets which are not occupied by the tension rods, and secured in

the ordinary manner, upon which they will themselves serve to hold the tube sheets in the sprung condition to which they have been brought by screwing up the nuts of the tension rods, and will be subject to the strain of compression induced by the tendency of the tube sheets to resume their original flat condition. The tension rods are then withdrawn, and tubes are fitted and secured in the holes in the tube sheets which had been occupied by them. The boiler, having been completed in other particulars of construction to which my invention does not relate, is now in readiness for operation, and when, under the influence of sufficiently high temperature, the expansion of the shell exceeds that of the tubes, the tensile strain on the latter induced by such unequal expansion is, as before explained, counteracted by the compression exerted by the elasticity of the outwardly sprung tube sheets.

The means herein set forth for practicing my invention are simple and convenient, but it will be obvious that my invention is not limited to its practice by the application of such specific means, as the necessary spring action of the tube sheets may be induced in any other suitable and preferred manner. It will further be apparent that my invention is applicable, without departure from its essential and characteristic principle and features, in the manufacture of tubular steam boilers of types which are structurally different from that which is herein exemplified.

I claim as my invention and desire to secure by Letters Patent:

1. The improvement in the manufacture of steam boilers which consists in the act of mechanically imposing a compressive strain upon the boiler tubes which opposes the tensile strain imposed upon them in service by the greater expansion of the boiler shell, and thereby produces a state or condition in which said tensile strain is compensated and counteracted.

2. The improvement in the manufacture of steam boilers which consists in the successive acts of springing the tube sheets outwardly, but without permanent set, and thereafter mechanically imposing a compressive strain upon the boiler tubes by securing their ends in the outwardly sprung tube sheets, thereby producing a state or condition in which the tensile strain upon the tubes due to the greater expansion of the shell is compensated and counteracted.

3. The improvement in the manufacture of steam boilers which consists in springing the tube sheets outwardly by exerting mechanically applied tension upon them, maintaining the tube sheets in sprung condition but without permanent set, inserting and securing a plurality of boiler tubes in the tube

5 sheets, detaching the tension applying means from the tube sheets, and inserting and securing boiler tubes in the holes of the tube sheets vacated by the detachment of the tension applying means.

10 4. The improvement in the manufacture of steam boilers which consists in springing the tube sheets outwardly by exerting tension upon a plurality of tension rods bearing on the inner sides of the tube sheets and the outer ends of the boiler shell, respectively, inserting and securing a plurality of boiler tubes in the tube sheets while the latter are maintained in sprung condition by the tension rods, detaching the tension rods from 15 the tube sheets, and inserting and securing boiler tubes in the holes of the tube sheets vacated by the detachment of the tension rods.

20 5. The improvement in the manufacture of steam boilers which consists in springing the tube sheets outwardly by exerting tension upon a plurality of tension rods bearing on the inner sides of the tube sheets and 25 the outer ends of the boiler shell, respectively, preventing coning of the middle portions of the tube sheets by extending a limit rod with adjusted outer bearings through tube holes therein, inserting and securing a 30 plurality of boiler tubes in the tube sheets while the latter are maintained in sprung

condition by the tension rods, detaching the tension rods and limit rod from the tube sheets, and inserting and securing boiler tubes in the holes of the tube sheets vacated by the detachment of the tension rods and limit rod. 35

6. A tubular steam boiler, the tubes of which are fixed in tube sheets which are sprung outwardly, but without permanent set, so as to be subject to a constant compressive strain, acting in opposition to the tensile strain imposed on the tubes in and by the expansion of the shell of the boiler. 40

7. A tubular steam boiler, the tube sheets 45 of which are sprung outwardly in the direction of the length of the tubes, so as to impose upon the tubes a constant compressive strain in opposition to the tensile strain imposed upon them by the expansion of the 50 boiler shell.

8. The combination, in a tubular steam boiler, of a shell, two tube sheets which are sprung outwardly, but without permanent set, in the direction of the length of the 55 tubes, and a plurality of boiler tubes which are connected, at their opposite ends, to said tube sheets.

DONALD R. MACBAIN.

Witnesses:

A. W. WOLCOTT,
W. F. BOEHRINGER.