What happened to the Sultana?

27 April 2015

Patrick Jennings

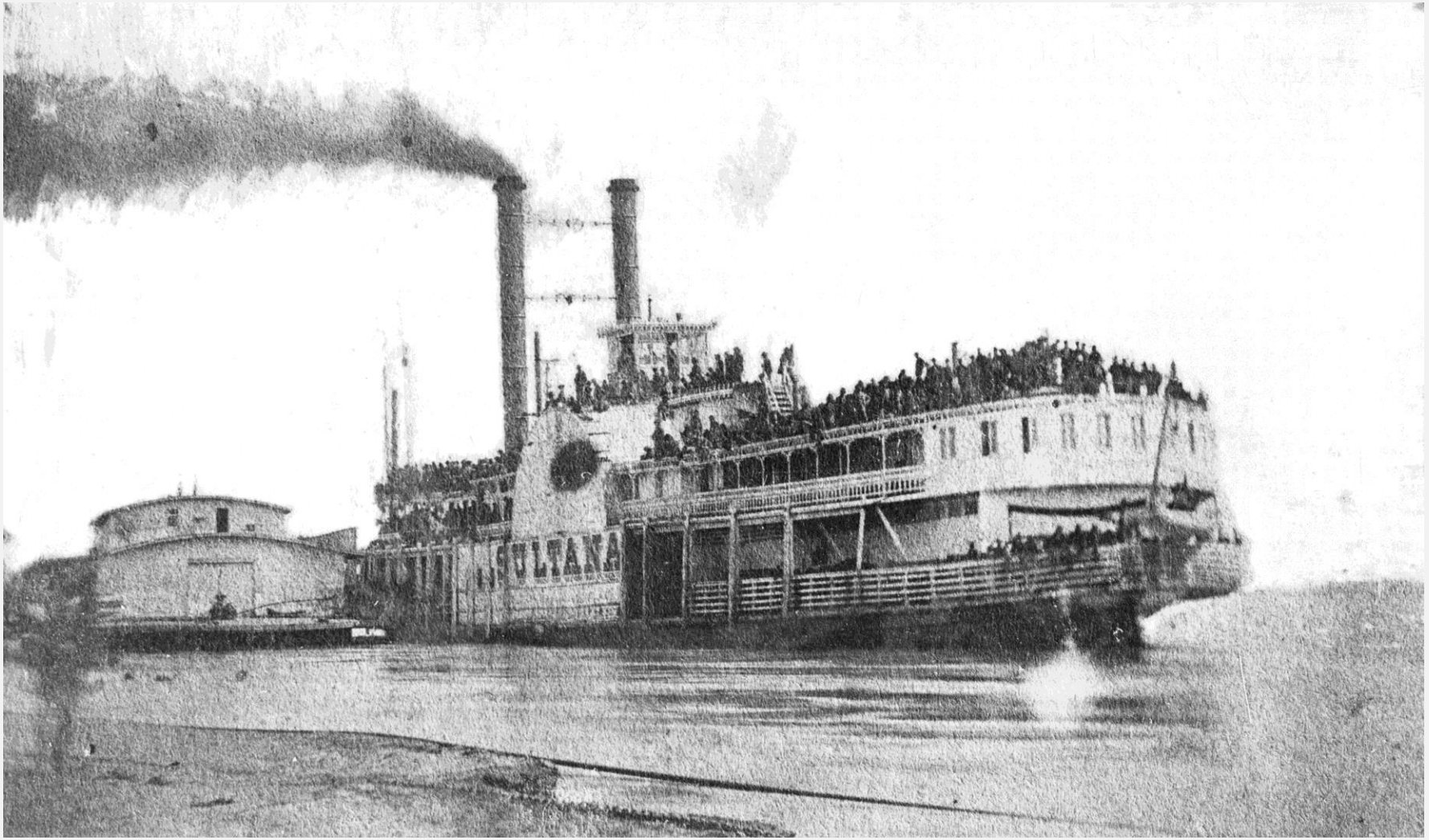
Hartford Steam Boiler

Risk Solutions

Munich RE

Sultana

Helena Arkansas



Careening Theory

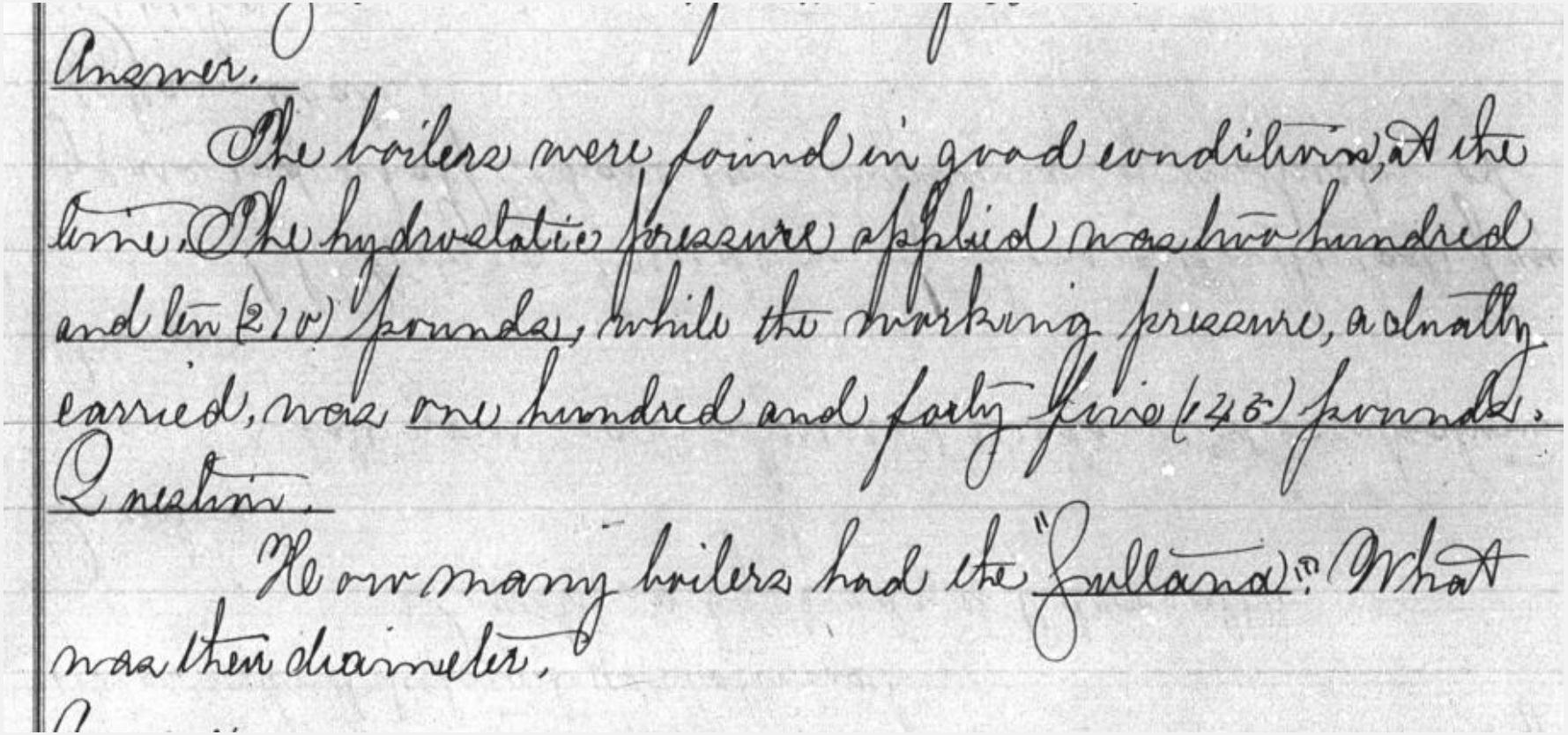
- Combination of low water and rocking of side to side
- Red Hot Iron / Water – sudden steam generation
- Discussed extensively in testimony
  - JJ Witzig, Isaac West, WB Richardson and Chief Engineer Wintringer discuss careening at some point
  - Many questions at the trial about careening
- HOWEVER:
  - No one mentioned the boat careening before the explosion.
  - Gen. Hoffman in a letter to the Secretary of War

    “There is nothing to show that there was any careening of the boat at the time of the disaster…”

Other Theories

1. Patch too thin – Testimony by JJ Witzig
   - ¼″ Iron
   - JJ Witzig – 100 psi max allowable
2. Sabotage
   - Coal torpedo
   - “Shell” found in wreckage
   - Report of a confession

Testimony



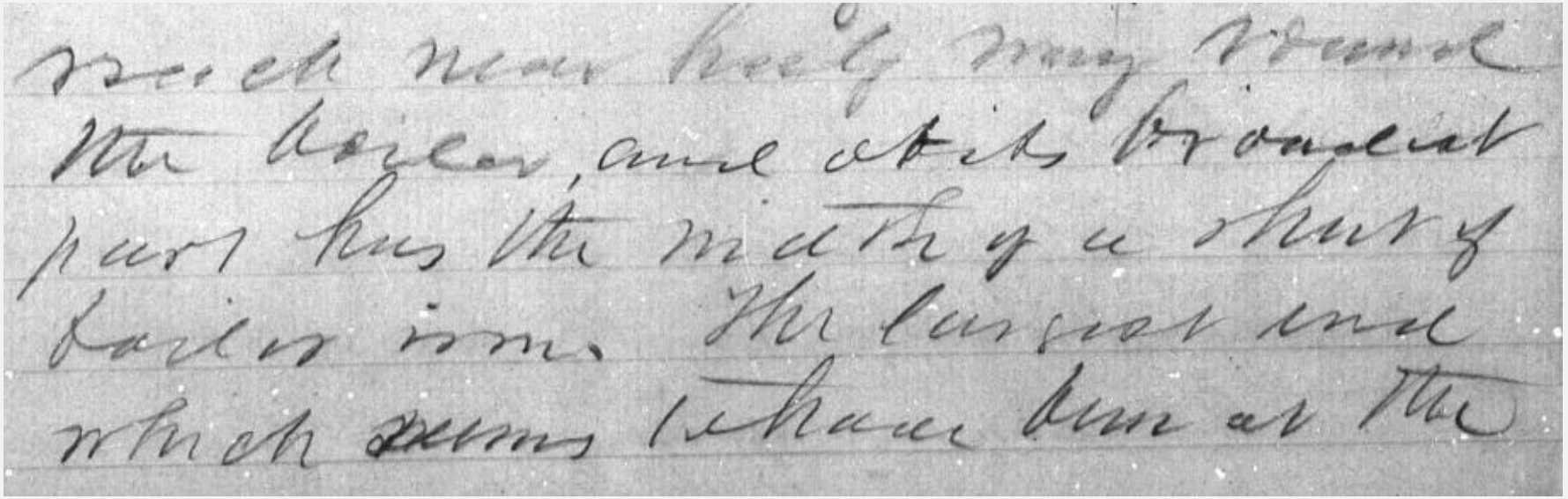
Answer.

The boilers were found in good condition, at the time. The hydrostatic pressure applied was two hundred and ten (210) pounds, while the working pressure, actually carried, was one hundred and forty five (145) pounds.

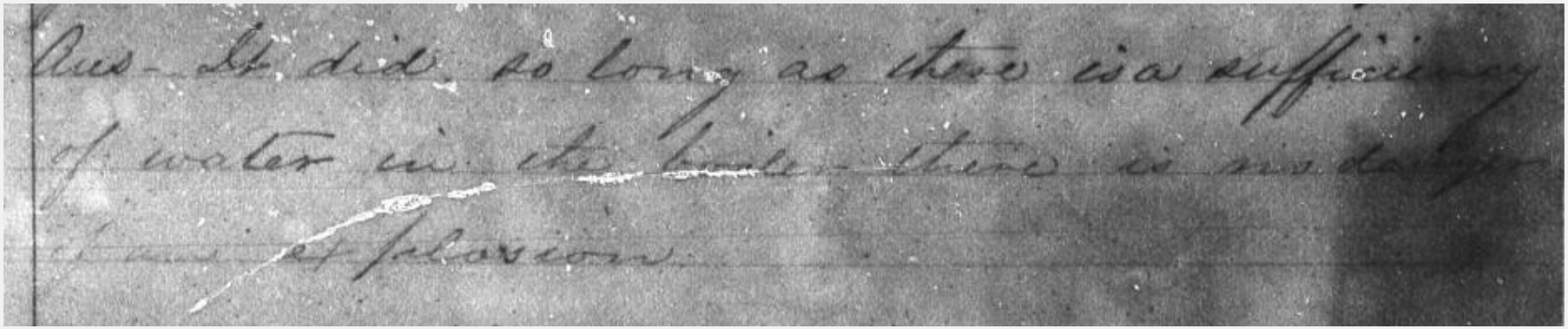
Question.

How many boilers had the "Fulland"? What was their diameter,

Testimony



RG Taylor – Boilermaker



Ans. – “It did. So long as there is a sufficiency of water in the boiler, there is no danger of an explosion.”

Issac West – Boilermaker and Engineer

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"It is my opinion that if the patching had been imperfectly done, and of insufficient strength to resist the ordinary pressure of the steam, the patch only would have blown off, and the injury would have stopped there."

Late 1800's Text References

Hartford Steam Boiler

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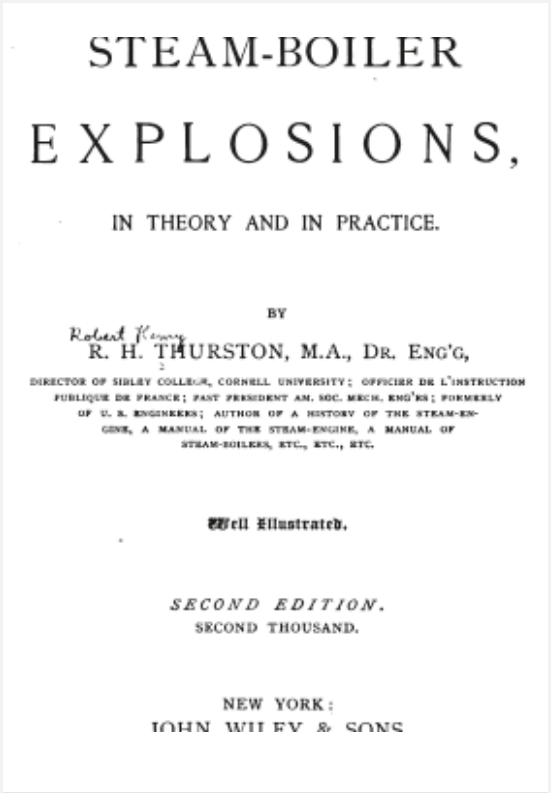

STEAM-BOILER

EXPLOSIONS,

IN THEORY AND IN PRACTICE.

BY

R. H. THURSTON, M.A., DR. ENG'G,

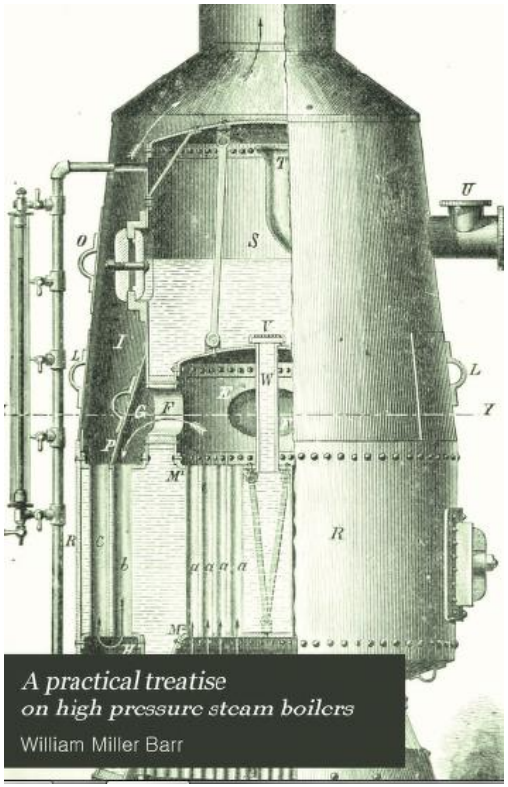
DIRECTOR OF SIBLEY COLLEGE, CORNELL UNIVERSITY; OFFICIER DE L'INSTRUCTION PUBLIQUE DE FRANCE; PAST PRESIDENT AM. SOC. MECH. ENG'RS; FORMERLY OF U. S. ENGINEERS; AUTHOR OF A HISTORY OF THE STEAM-ENGINE, A MANUAL OF THE STEAM-ENGINE, A MANUAL OF STEAM-BOILERS, ETC., ETC., ETC.

Well Illustrated.

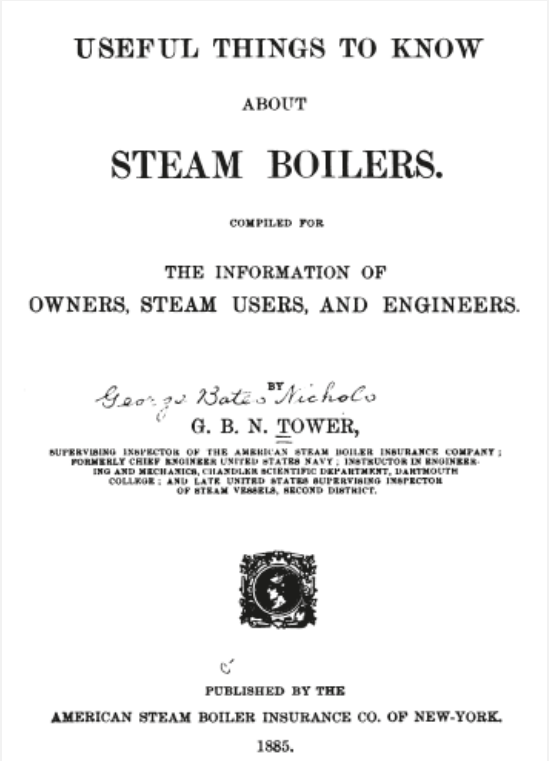
SECOND EDITION.
SECOND THOUSAND.

NEW YORK:
JOHN WILEY & SONS

- Robert H. Thurston – First President of ASME
- Copyright – 1887



- Different irons used in boiler construction
- Copyright – 1879


USEFUL THINGS TO KNOW

ABOUT

STEAM BOILERS.

COMPILED FOR

THE INFORMATION OF

OWNERS, STEAM USERS, AND ENGINEERS.

BY

G. B. N. TOWER,

SUPERVISING INSPECTOR OF THE AMERICAN STEAM BOILER INSURANCE COMPANY; FORMERLY CHIEF ENGINEER UNITED STATES NAVY; INSTRUCTOR IN ENGINEERING AND MECHANICS, CHANDLER SCIENTIFIC DEPARTMENT, DARTMOUTH COLLEGE; AND LATE UNITED STATES SUPERVISING INSPECTOR OF STEAM VESSELS, SECOND DISTRICT.

PUBLISHED BY THE

AMERICAN STEAM BOILER INSURANCE CO. OF NEW-YORK.

1885.

- General overview
- Copyright – 1885

Stored Energy of Steam Boilers
Thurston

TOTAL STORED ENERGY OF STEAM BOILERS.—*Continued.*

Type.	Stored Energy in (available)			Energy per lb. of		Max. Height of Project'n.		Initial Velocity	
	Water.	Steam.	Total.	B'l'r	Tot W't	B'l'r	Tot	B'l'r	Tot.
	Foot lbs.			Ft. lbs		Feet.		Feet per Second.	
1 Plain Cylinder...	46,605,200	676,698	47,281,898	18913	5714	18913	5714	1103	606
2 Cornish.	57,570,750	709,310	58,260,060	3431	1314	3431	1314	471	290
3 Two-flue Cyl'der	80,572,050	2,377,357	82,949,407	12243	6076	12243	6076	888	625
4 Plain Tubular. .	50,008,790	1,022,731	51,031,521	5372	2871	5372	2871	588	430
5 Locomotive.....	52,561,075	1,483,896	54,044,971	2786	2189	2786	2189	423	375
6 "	69,148,790	2,136,802	71,284,592	2851	2231	2851	2231	428	379

- First Steam Studies – 1860's – Rankine
- Stored Energy –
  - 97% in water
- Converting the stored energy (Foot lbs) to height.
- Tubular Boiler – 5372 ft.
- Low Water
  - "Some authorities now question the possibility of its action at all"

Explosion Theory – Demonstration

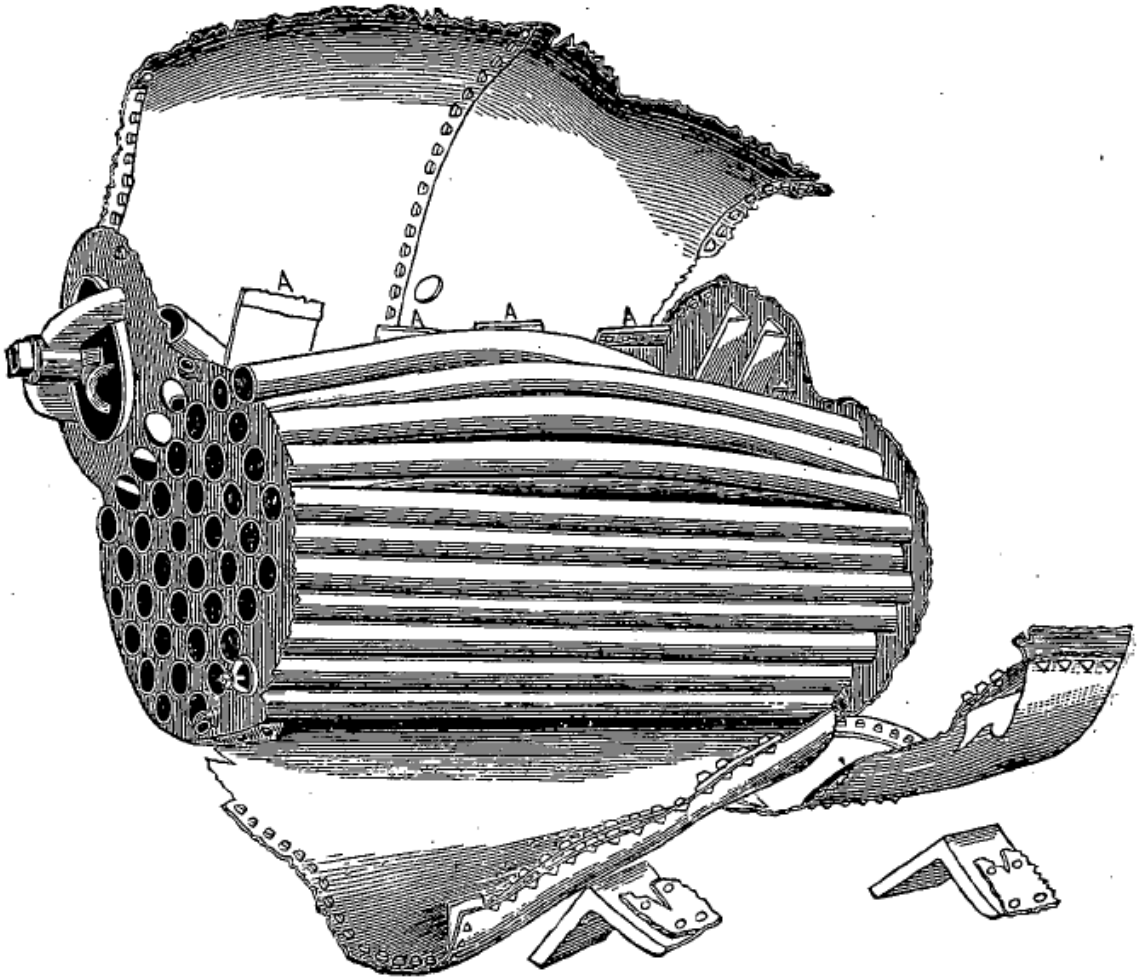


FIG. 1.

Sultana Boilers

- 4 Firetube
- Charcoal hammered No. 1 iron, 17/48″ thick
- 46″ OD, 18′ long,
- 24- 5″ flues
- Design 145 psig
- 2 Safety Valves
- 2 Water, 1 Steam Gage
- “Safety Guard” Fusible Plug
- In poor condition

Charcoal Hammered No. 1 (Wrought iron)

- Non-homogenous
- Inclusions
- Brittle
- By 1879
  - “...not a suitable iron for boiler construction”
  - “...having but little elasticity and breaking with a sudden jerk”.
  - “brittle character and unfit for use in a boiler”
- Replaced by “Flange Iron”

Mississippi River Water

- Boiler Make up – straight river water
- Boilers cleaned in New Orleans and then again in Vicksburg
- 500 mg/liter (2011 USGS Data)
- ½ lb sediment per 1000 lbs water

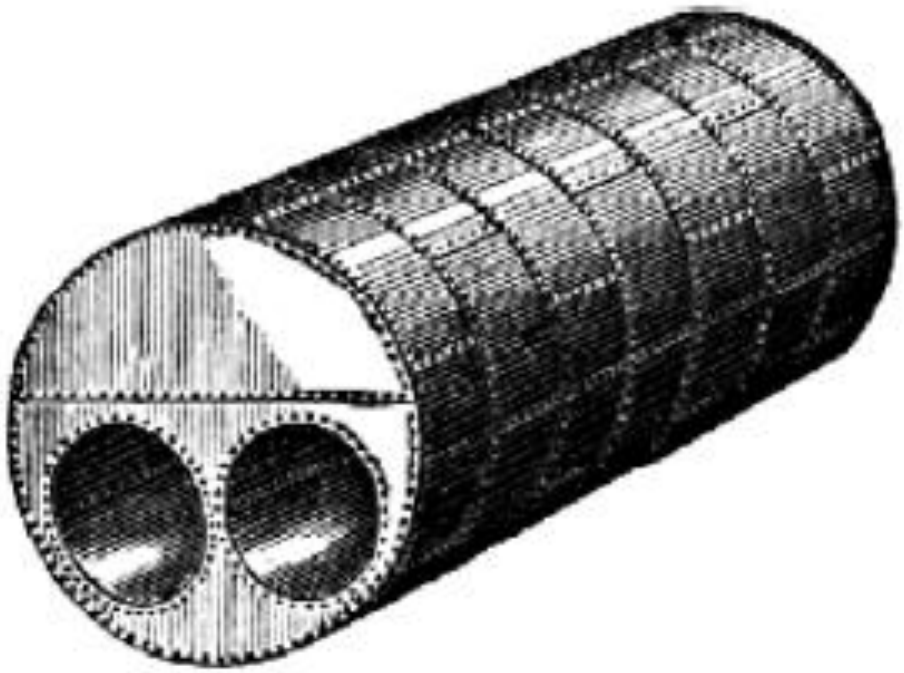
Scale or “Incrustation”

Fig. 73.

The whole bottom of a boiler is sometimes injured, and the plates buckled and the seams sprung, from the accumulation of mud. One case may be mentioned where the water was

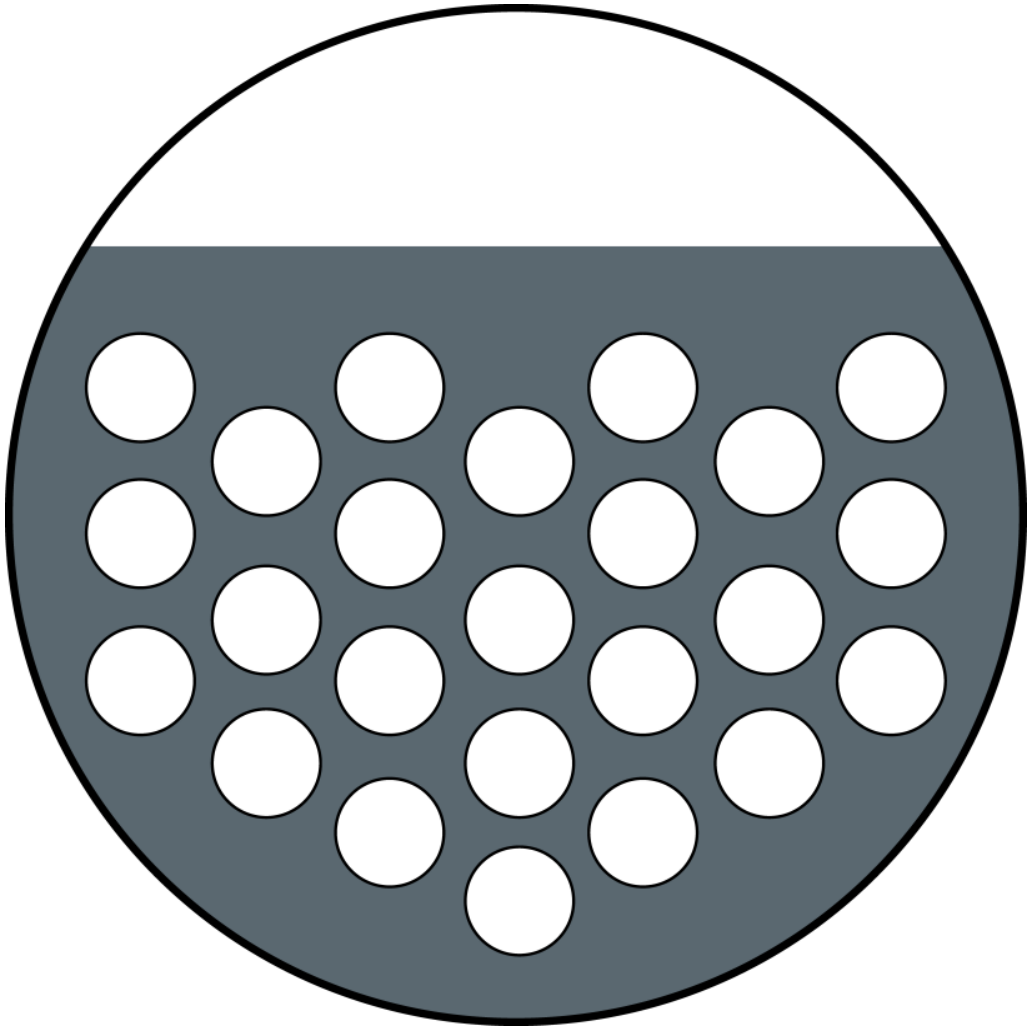
Scale or “Incrustation”

Boiler Design



- 24 – 5″ Tubes
- Bottom – cleaned by a shell broom
- Top – small boys scrape them down
- 1866 – 3 Additional explosions of tubular boilers
- Rapid removal of tubular boilers from the Mississippi River
- Single Lap

Boiler Design



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Root Cause Summary

1. Quality of iron
   - Brittle – Especially when overheated
2. Mississippi River
   - Mud
3. Design
   - Not suited for conditions – hard to clean
   - Tubular boilers removed from Mississippi River Steamboats

“Dangerous Conditions”

Hartford Steam Boiler

Munich RE

Yearly Summary of Inspections for the Year 1879.

Whole number of visits during the year, - - - - - 17,179
Whole number of inspections, - - - - - - - 36,169
Whole number of thorough annual inspections, - - - - 13,045
Whole number of boilers subjected to hydraulic test, mostly new or repaired, 2,540

Whole number of defects discovered, 16,238. Dangerous defects, 3,816.

Details for the year 1879.

	In all.	Dangerous.		In all.	Dangerous.
Furnaces out of shape, -	848	195	Cases of internal grooving, -	126	56
Fractures in all, - - -	1,387	684	Water gauges out of order, -	405	133
Burned plates, - - -	963	302	Blow-out ap'atus out of order,	181	61
Blistered plates, - -	2,597	334	Safety-valve overloaded, -	234	102
Cases of deposit of sediment,	2,177	456	Pressure gauges out of order,	1,393	298
Cases of incrustation & scale,	2,791	388	Boilers without gauges, -	714	8
Cases of external corrosion,	1,162	352	Cases of deficiency of water, -	55	38
Cases of internal corrosion, -	743	188	Broken braces and stays, -	462	221

- Burnt Plates
- Incomplete repair
- Data from England indicated that 50% of explosions in one year initiated at a seam.
- Locomotive Data – 3816 Dangerous Conditions
- 1% – Deficiency of water
- 16% – Burned / blistered
- 22% – Sediment / scale

Explosions
Year Ending Oct. 1, 1868

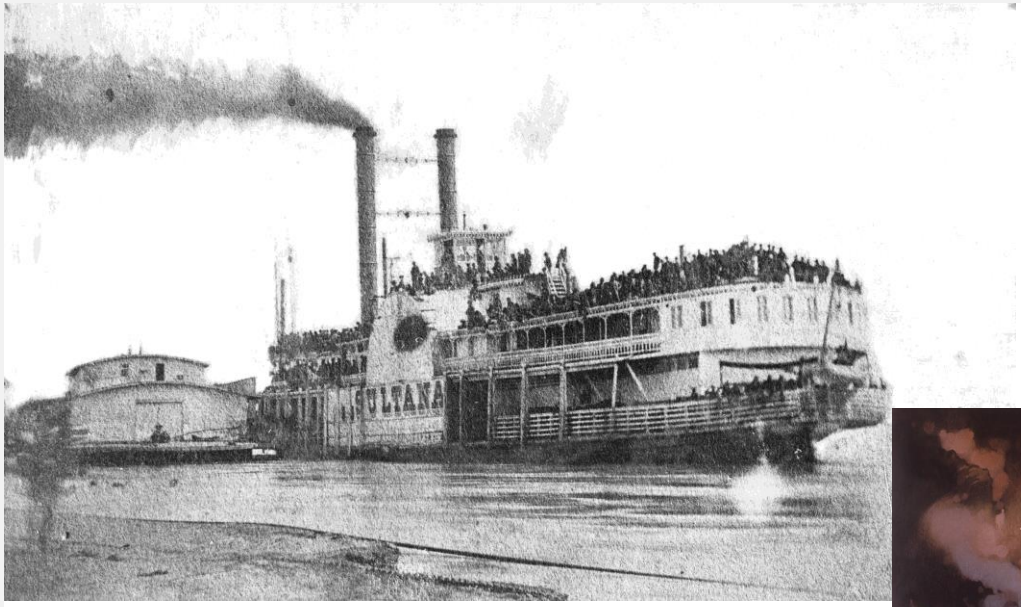
Hartford Steam Boiler

Munich RE

	Number Exploded.	Number killed.	Number wounded.
R. R. Locomotives,	23	25	36
Steam Saw Mills,	13	40	42
Steam Boats,	10	100	50
Iron and metal Works,	10	31	45
Wood-working Shops,	6	1	10
Steam Tugs and Propellers,	8	23	12
Mills of various kinds,	9	5	22
Distilleries and Breweries,	3	4	13
Rendering Houses,	2	1	4
Domestic Boilers for heating,	2	3	1
Dock Engines,	3	5	6
Steam Fire Engines,	2	5	16
Cotton Press,	1	2	1
Miscellaneous,	2	1	3
Total,	94	246	261

Hartford Steam Boiler, ASME and NBIC

- Polytechnic Club – 1857
- HSB incorporated in 1866
- First Meeting of ASME – 1880
- Hartford Standards – 1889
- ASME – First Boiler & Pressure Vessel Code – 1915
- National Board – First meeting of Chief Inspectors -1919



Thank you very much for your attention

Pat Jennings

1866

Hartford Steam Boiler

Risk Solutions

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